State of New York—Department of Agriculture

TWENTY-FIFTH ANNUAL REPORT

OF THE

BOARD OF CONTROL

OF THE

NEW YORK

Agricultural Experiment Station

(GENEVA. ONTARIO COUNTY)

FOR THE YEAR 1906

With Reports of Director and Other Officers

TRANSMITTED TO THE LEGISLATURE JANUARY 14, 1907

ALBANY
J. B. LYON COMPANY, STATE PRINTERS
1907

STATE OF NEW YORK

No. 20.

IN ASSEMBLY

JANUARY 14, 1907.

TWENTY-FIFTH ANNUAL REPORT

OF THE

BOARD OF CONTROL OF THE NEW YORK AGRICULTURAL EXPERIMENT STATION

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,

ALBANY, N. Y., *January* 14, 1907.

To the Assembly of the State of New York:

I have the honor to herewith submit the Twenty-fifth Annual Report of the Director and Board of Control of the New York Agricultural Experiment Station at Geneva, N. Y., in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,

CHARLES A. WIETING,

Commissioner of Agriculture.

NEW YORK AGRICULTURAL EXPERIMENT STATION.

GENEVA, N. Y., *January* 1, 1907.

Hon. CHARLES A. WIETING, *Commissioner of Agriculture, Albany, N. Y.:*

Dear Sir.—I have the honor to transmit herewith the report of the Director of the New York Agricultural Experiment Station for the year 1906, in accordance with the provisions of chapter 439, Laws of 1904.

Yours respectfully,

S. H. HAMMOND,

President, Board of Control.

1906.

ORGANIZATION OF THE STATION.

BOARD OF CONTROL.

Governor FRANK W. HIGGINS, Albany.
Commissioner CHARLES A. WIETING, Albany.
STEPHEN H. HAMMOND, Geneva.
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OFFICERS OF THE BOARD.

STEPHEN H. HAMMOND, *President.*

WILLIAM O'HANLON, *Secretary and Treasurer.*

EXECUTIVE COMMITTEE.

STEPHEN H. HAMMOND, LYMAN P. HAVILAND, THOMAS B. WILSON.

STATION STAFF.

WHITMAN H. JORDAN, Sc. D., *Director.*

GEORGE W. CHURCHILL, *Agriculturist and Superintendent of Labor.*
WILLIAM P. WHEELER, *First Assistant (Animal Industry).*
FRED C. STEWART, M. S., *Botanist.*
[1]HARRY J. EUSTACE, B. S.,
[2]H. TALBOT FRENCH, B. S., *Assistant Botanists.*
LUCIUS L. VAN SLYKE, Ph. D., *Chemist.*
[3]EDWIN B. HART, *Associate Chemist.*
ERNEST L. BAKER, B. S.,
ALFRED W. BOSWORTH, B. S.,
[4]WILLIAM E. TOTTINGHAM, B. S.,
ARTHUR W. CLARK, B. S.,
[5]ANTON R. ROSE, B. S., *Assistant Chemists.*
HARRY A. HARDING, M. S., *Bacteriologist.*
MARTIN J. PRUCHA, Ph. B.,
[6]JAMES WILSON, B. S., *Assistant Bacteriologists.*
GEORGE A. SMITH, *Dairy Expert.*
FRANK H. HALL, B. S., *Editor and Librarian.*
PERCIVAL J. PARROTT, M. A., *Entomologist.*
HAROLD E. HODGKINS, B. S.,
[7]WILLIAM J. SCHOENE, B. Agr., *Assistant Entomologists.*
ULYSSES P. HEDRICK, M. S., *Horticulturist.*
NATHANIEL O. BOOTH, B. Agr.,
[8]RICHARD WELLINGTON, B. S., *Assistant Horticulturists.*
ORRIN M. TAYLOR, *Foreman in Horticulture.*
[9]F. ATWOOD SIRRINE, M. S., *Special Agent.*
FRANK E. NEWTON,
JENNIE TERWILLIGER,
[10]GEORGE A. MENARD,
[11]WILLARD F. PATCHIN, *Stenographers.*
ADIN H. HORTON, *Computer and Mailing Clerk.*
JULIA A. HOEY, *Junior Clerk.*

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[1]Resigned November 1, 1906.
[2]Appointed July 16, 1906.
[3]Resigned October 1, 1906.
[4]Resigned September 15, 1906.
[5]Appointed February 1, 1906.
[6]Appointed July 15, 1906.
[7]Appointed July 7, 1906; previously Student Assistant in Entomology.
[8]Appointed July 15, 1906.
[9]Riverhead, N. Y.
[10]Appointed June 1, 1906; resigned September 15, 1906.
[11]Appointed November 22, 1906.

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Twenty-Fifth Annual Report

of the

Board of Control of the New York Agricultural Experiment Station.

TREASURER'S REPORT.

Geneva, N. Y., *October* 1, 1906.

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ending September 30, 1906:

Maintenance Fund—Necessary Expense.

Receipts.

1905.		APPROPRIATION 1905–1906.	*Dr.*
Oct.	1.	To balance on hand..................	$20 00
		Amount received from Comptroller....	15,000 00
			$15,020 00

Expenditures.	*Cr.*
By building and repairs..............	$138 13
By chemical supplies	259 18
By contingent expenses	2,222 07
By feeding stuffs	781 47
By fertilizers	234 94
By freight and express..............	208 68

By furniture and fixtures	$1,224 21
By heat, light and water	711 13
By library	1,092 50
By live stock	332 00
By postage and stationery	918 11
By publications	2,629 03
By scientific apparatus	35 58
By seeds, plants, and sundry supplies	1,894 22
By tools, implements, and machinery	471 60
By traveling expenses	1,867 11
Balance, October 1, 1906	04
	$15,020 00

GENERAL EXPENSES—HEAT, LIGHT, WATER, APPARATUS, REPAIRS, ETC.

1905.		*Receipts.*	*Dr.*
Oct.	1.	To amount on hand	$44 51
		To amount received from Comptroller	4,000 00
			$4,044 51

Expenditures.	*Cr.*
By buildings and repairs	$1,035 56
By chemical supplies	18 00
By contingent expenses	315 25
By furniture and fixtures	189 44
By heat, light and water	2,354 17
By scientific apparatus	64 45
By seeds, plants, and sundry supplies	21 23
By tools, implements, and machinery	1 90
Balance, October 1, 1906	44 51
	$4,044 51

SPECIAL FUND—HORTICULTURAL INVESTIGATIONS.

1905.	*Receipts*, 1905–1906.	*Dr.*
Oct.	1. To balance on hand	$6 22
	To amount received from Comptroller	8,000 00
		$8,006 22

	Expenditures.	*Cr.*
	By chemical supplies	$0 10
	By contingent expenses	1,036 95
	By fertilizers	37 00
	By freight and express	20 04
	By postage and stationery	18 70
	By publications	419 63
	By salaries	5,632 39
	By scientific apparatus	11 45
	By seeds, plants, and sundry supplies	118 95
	By tools, implements, and machinery	10 58
	By traveling expenses	482 91
	Balance, October 1, 1906	217 52
		$8,006 22

FERTILIZER INSPECTION.

1905.	*Receipts.*	*Dr.*
Oct.	1. To balance on hand	$1,805 90
	To Balance in State Treasury	3,000 00
	To amount received from Comptroller	9,000 00
		$13,805 90

	Expenditures.	*Cr.*
	By chemical supplies	$449 65
	By contingent expenses	6 94
	By feeding stuffs	2 70
	By freight and express	224 98
	By heat, light, and water	423 87
	By library	50

	By postage and stationery............	$26 70
	By publications	1,640 44
	By salaries	6,879 30
	By seeds, plants, and sundry supplies..	1 40
	By traveling expenses	1,233 23
	Balance, October 1, 1906.............	2,916 19
		$13,805 90

(Four thousand dollars with N. Y. State Treasury.)

CONCENTRATED FEEDING STUFFS INSPECTION.

1905.	*Receipts.*	*Dr.*
Oct. 1.	To balance on hand..................	$582 30
	To amount received from Comptroller..	3,500 00
		$4,082 30

	Expenditures.	*Cr.*
	By contingent expenses	$7 60
	By freight and express...............	86 50
	By heat, light, and water............	59 63
	By postage and stationery............	38 30
	By publications	629 00
	By salaries	1,645 00
	By seeds, plants, and sundry supplies..	2 90
	By traveling expenses	505 47
	Balance, October 1, 1906.............	1,107 90
		$4,082 30

SALARIES.

Receipts.

1905.	APPROPRIATION, 1905–1906.	*Dr.*
Oct. 1.	To balance	$1,427 46
	To amount received from Comptroller..	23,000 00
		$24,427 46

		Expenditures.	*Cr.*
1905–6.		By salaries	$23,591 76
		Balance, October 1, 1906.............	835 70
			$24,427 46

LABOR.

Receipts.

		APPROPRIATION, 1905–1906.	*Dr.*
1905.			
Oct.	1.	To balance	1,279 31
		To amount received from Comptroller.	13,000 00
			$14,279 31

		Expenditures.	*Cr.*
1905–6.		By salaries	$12,278 32
		Balance, October 1, 1906.............	2,000 99
			$14,279 31

		INSURANCE MONEY.	*Dr.*
1905.			
Oct.	1.	To balance..........................	$187 07

	Expenditures.	*Cr.*
	By tools and machinery..............	$165 00
	Balance, October 1, 1906.............	22 07
		$187 07

NEW YORK AGRICULTURAL EXPERIMENT STATION.

APPROPRIATION, 1905–1906.	*Dr.*
To receipts from the Treasurer of the United States as per appropriation for fiscal year ended June 30, 1906, as per act of Congress, approved March 2, 1887	$1,500 00

	Cr.
By salaries	$909 49
By publications	205 40
By postage and stationery	55 20
By freight and express	49 65
By chemical supplies	12 75
By seed, plants, and sundry supplies	5 68
By feeding stuffs	39 80
By library	88 44
By live stock	1 50
By traveling expenses	8 02
By contingent expenses	121 84
By balance, October 1, 1906	2 23
	$1,500 00

ADAMS' FUND—NEW YORK AGRICULTURAL EXPERIMENT STATION—APPROPRIATION, 1905–1906.

	Dr.
To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1906, as per act of Congress, approved March 16, 1906	$500 00

	Cr.
By postage and stationery	$0 01
By chemical supplies	499 99
	$500 00

All expenditures are supported by vouchers approved by the Auditing Committee of the Board of Control and have been forwarded to the Comptroller of the State of New York.

WILLIAM O'HANLON,
Treasurer.

DIRECTOR'S REPORT FOR 1906.*

To the Honorable Board of Control of the New York Agricultural Experiment Station:

GENTLEMEN.—At the close of the year 1906 I again have the honor and privilege of presenting my annual report concerning the work, condition, and needs of the institution under your charge.

The activities of the Station have not diminished in their scope, which is broad, nor have they lessened, it is to be hoped, in their importance to agricultural practice. The continued approval of the Station efforts by the agricultural public is a reasonable assurance that our work is regarded as helpful. It gives me great pleasure to report that the condition of the Station is gratifying as to the personnel of its staff and the character of its equipment. As to needs, it is to be said that the institution is still in the process of development and, therefore, real needs exist if there is to be progress in efficiency and completeness of organization. In presenting these matters to your consideration, I am acting under the conviction that I am merely fulfilling my duty to you and to the people of the State. After you have made the recommendations which in your judgment appear to be wise, it remains for the people to determine, through their representatives in the law-making body, what measures shall be adopted.

ADMINISTRATION.

CHANGES IN THE STATION STAFF.

During the past year, the various agricultural colleges and experiment stations in other states have displayed their usual activity in seeking for men with whom to strengthen their staffs and in consequence several members of the Station staff have accepted positions elsewhere.

Mr. Edwin B. Hart, who was connected with the Chemical Department of the Station for nine years, was called to the responsible position of Professor of Agricultural Chemistry and Chemist

*A corrected reprint of Bulletin No. 284.

to the experiment station of the University of Wisconsin. This call came, without question, in consequence of the high character of the work which Mr. Hart had accomplished during his connection with us and is a worthy recognition of the value which the experiment stations are coming to place upon unmistakeable evidences of research ability.

Mr. William E. Tottingham, whose connection with the chemical work of the Station had been brief but entirely satisfactory, was also elected to the position of instructor in the University of Wisconsin.

Mr. Harry J. Eustace, who has been connected with the botanical work of the Station since July 1, 1901, accepted a position in the U. S. Department of Agriculture. This appointment came, as was the case with Mr. Hart, as a merited recognition of efficient and highly satisfactory service.

Because of the present demand for men who are properly fitted to take up experiment station work, these vacancies are not yet filled, but steps have been taken for so doing.

The increased funds placed at the disposal of the Station by the Legislature of 1906, has made possible the following additions to the Station staff with a view to a material increase in the experiments and demonstrations that are being made along various lines in different parts of the State:

G. Talbot French, B. S., Assistant Botanist, a graduate of the Massachusetts Agricultural College.

James Wilson, B. S., Assistant Bacteriologist, a graduate of the Oklahoma Agricultural and Mechanical College.

Richard Wellington, B. S., Assistant Horticulturist, a graduate of the Massachusetts Agricultural College.

William J. Schoene, B. Agr., Assistant Entomologist, a graduate of the Agricultural and Mechanical College of Kentucky.

MAINTENANCE FUNDS.

In accordance with your action, the Legislature of 1906 was asked to increase the maintenance funds of the institution by the sum of $25,000. After a careful and very friendly consideration of the request by the legislative committees having the finances of the State in charge, it was decided that an increase of $10,000 was all that the situation would justify, a result which was accepted

by all friends of the Station as giving evidence of a spirit of confidence in our institution. The various funds that were appropriated for the maintenance of the Station during the fiscal year beginning October 1, 1906, were as follows:

Salaries	$28,000
Labor	13,000
Expenses of various departments of research	20,000
General expense, heat, light, water, apparatus, repairs, etc.	4,000
Expense of horticultural investigation	8,000
Fertilizer inspection	10,000
Feeding stuffs inspection	3,500

By action of your Board the Legislature is to be asked to appropriate the same sums for the fiscal year beginning October 1, 1907. While larger amounts of money could be efficiently and profitably used, it is felt that the constituency of the Station should be given convincing evidence that the increase with which we have just been favored is being used to good advantage before asking for any further endowment.

MAILING LIST.

The growth of the mailing list, though not now as rapid as at some times in the past, has continued steadily during the year 1906. The number of names on this list is now as follows:

BULLETIN LISTS, DECEMBER 15, 1906.

Popular Bulletins.

Residents of New York	36,880
Residents of other states	2,331
Newspapers	757
Experiment stations and their staffs	1,187
Miscellaneous	131
Total	41,286

Complete Bulletins.

Experiment stations and their staffs	1,187
Libraries, scientists, etc.	170
Foreign list	262
Individuals	3,172
Miscellaneous	131
Total	4,922

TWENTY-FIFTH ANNIVERSARY OF STATION'S ESTABLISHMENT.

On March 1, 1907, this institution will have completed twenty-five years of organized existence. It is purposed to prepare a review of the history of the Station and what it has accomplished in the interests of agriculture during this period, to be presented to the Legislature as a part of the Annual Report for 1906.

It seems desirable, also, that the twenty-fifth anniversary of the Station should otherwise be noticed in some special manner. Such an occasion would give an opportunity for assembling our friends and for bringing to the notice of the public and of the leading men of the State the results we have accomplished and our plans for the future. An event of this kind can be made a source of inspiration to those who bear the responsibilities of the Station management and a means of enlarging public appreciation of the services that we are able to render. My recommendation that plans be perfected for holding anniversary exercises at some date in May or June of 1907, having been adopted by you, measures are now being taken in preparation for this event.

ADDITIONS TO THE BUILDING EQUIPMENT.

It is a matter for congratulation, I am convinced, that your Board has decided to ask for funds with which to make additions to the building equipment of the Station. The sum which the State has so far invested in buildings on the Station grounds is less than $150,000, which, is little more than half what some states have appropriated to a single building for the uses of agricultural investigation or instruction. There appears to be no reason, then, why you should hesitate about urging a generous increase to our building equipment.

An auditorium.—So far in its history the Station has suffered the disadvantage quite unusual to institutions of this class, of not having on its grounds an auditorium where audiences of any considerable size can meet. Such assemblages as have met with us have held their sessions either in the open air or, as was the case on one occasion, under a large tent. This fact has placed limitations upon our relations to the public and in view of the enlarging responsibilities of the institution, constitutes a disadvantage that is increasingly evident. There are several agricultural organiza-

tions in the State that would meet with us occasionally and probably some would be glad to make our grounds a permanent meeting place. The means are few by which we could more effetctively bring the public into an intelligent touch with our work. This is true not only of agriculture but of the educational efforts of the schools to which, I believe, this Station will in time come to sustain much closer relations.

Additional dwelling houses.—Your decision to continue the policy of erecting dwelling houses on the Station grounds for the accommodation of members of the staff is, I believe, a wise one. It is a lamentable fact that in the past the Station has lost several able men because of the larger attractions offered by other states. Just now the rapid growth of the United States Department of Agriculture and the general increase in station funds as provided by the Adams Act are causing an active search among the altogether too scanty number of well equipped men for material with which to strengthen staffs of teachers and investigators. It behooves our own State to resist the well meant blandishments of outside institutions and to retain in her employ those persons who are now rendering her efficient service. Real ability should not be assessed at a higher value in any state in the Union. Because of the difficulty in securing and retaining in Geneva desirable rentals conveniently located, nothing would more largely promote a feeling of contentment among the members of the Station staff than comfortable and permanent homes. In my last two reports I have set forth other reasons why the assembling of the homes of the Station staff upon the Station grounds would be a distinct advantage. I trust that our needs in this direction will be clearly recognized by the law-making body.

FRUIT PUBLICATIONS.

The publication known as "The Apples of New York" has met with a warm reception not only by horticultural experts but by the agricultural public. This was prepared as the first of a series that is to include the principal fruits of the State. The horticultural department is now ready to proceed with the preparation of a volume devoted to grapes that will be submitted to the Commissioner of Agriculture as a part of our annual report. It is necessary,

however, that at least $2,500 become available during 1907 to be applied to editorial services and the preparation of plates. The horticultural staff of the Station can not, without aid, perform the large labor involved in such a work and at the same time maintain the regular activities of the horticultural department.

THE GRADUATE SCHOOL OF AGRICULTURE.

Under the auspices and general direction of the American Association of Agricultural Colleges and Experiment Stations, there has been organized what is known as the Graduate School of Agriculture. The object of this school is to present to such members of the college faculties and station staffs as may desire it, advanced instruction and discussions along the lines that are pertinent to teaching and investigation in agriculture. Two sessions of the school have been held, one at the University of Ohio and the other at the University of Illinois, the results of which appear to abundantly justify the effort. The faculty of instruction consists of men selected from the various institutions represented in the Association, whose compensaion is merely nominal.

It is obvious that comparatively few of the colleges and stations are in a position to offer to this school a meeting place and the necessary financial support. Among the institutions that can do this is Cornell University, and it is proposed by Dean Bailey of the New York State College of Agriculture to invite this school to New York for the year 1908. The question was raised as to whether this institution desired to co-operate in this invitation and share in the responsibilities, financial and otherwise. My personal opinion, as expressed to your Board, is that it would be profitable for us to do so because of the impetus it would give to our work. Indeed, it seems as if the force of circumstances practically compels this Station to give its aid in this matter. Acting under your authority, I joined with Dean Bailey, at the recent meeting of the College and Station Association at Baton Rouge, in extending an invitation to the Graduate School to meet in New York in 1908 and hold part of its sessions at the Station.

DEMONSTRATION EXPERIMENTS.

The experiments that are being conducted in various parts of the State in testing the value of methods that relate to agricultural

practice have continued along practically the same lines and to about the same extent as during 1904 and 1905. It is the policy of the Station to enlarge its work of this character. Indeed it was with this understanding that the Legislature of 1906 was asked to increase the working funds of the Station. As the increase of funds that was granted did not take effect until October 1, 1906, it was not possible to add to our list of experiments during the season of 1906. It is expected, however, that a materially larger number of outside experiments, more widely distributed, will be carried on during the season of 1907.

There is given in this connection a list of the outside experiments for 1906. In most cases these were conducted in co-operation with the farmers on whose land the experiments were located and I desire in this connection to express for myself and associates our high appreciation of the way in which our efforts have been seconded by the gentlemen with whom we have co-operated.

POTATO SPRAYING EXPERIMENTS.

Chafee	R. M. Howell
Silver Springs	F. J. Austin
Batavia	J. H. Miller
Avoca	G. A. Fox
Nichols	D. Dean
Cortland	G. H. Hyde
Memphis	M. Bowes
Ogdensburg	A. Tuck
Chateaugay	Oliver Smith & Son
Peru	Datus Clark
Hebron	W. B. & W. R. Shaw
Woodbury	A. & T. VanSise
Sagaponack	P. Roesel
Riverhead	I. M. Young
"	F. A. Sirrine
Odessa	O. S. Benson

ORCHARD MANAGEMENT.

South Greece	W. D. Auchter
Syracuse	Grant Hitchings

ECONOMY OF DWARF ORCHARDS.

Fayetteville	F. E. Dawley
Carlton Station	Albert Wood & Son
Kinderhook	Edward VanAlstyne

EXPERIMENT WITH GRAPE STOCKS.

Portland	I. A. Wilcox

ALFALFA DODDER EXPERIMENTS.

Dewitt	J. A. Planck
Fayetteville	D. H. Wells
Oakfield	B. W. Taylor
Geneva	C. K. Scoon

SAN JOSE SCALE.

Youngstown	A. H. Dutton
Geneva	Alfred Lewis
Huntington	Gilbert Scudder
Yorktown	Floyd White
Riverhead	F. A. Sirrine
Laurel	S. M. Woodhull
Wading River	E. S. Miller

LEAF BLISTER-MITE.

Williamson	W. P. Rogers

METHODS OF APPLYING FERTILIZERS TO POTATOES.

Baiting Hollow	D. L. Downs
Cutchogue	W. A. Fleet
Riverhead	F. A. Sirrine

Besides the above list, sixty-three farmers were furnished with materials for soil inoculation, with the understanding that they would make certain observations and report them to the Station as to the growth of the alfalfa under the various conditions established.

INVESTIGATION.

The following summaries briefly touch on some of the more important results discussed in the bulletins issued during 1906. Many more lines of work are being prosecuted than are mentioned in this connection. It is the policy of the Station to include in its publications only those results that are of scientific or practical interest and that are well substantiated by sufficient reliable data.

DEPARTMENT OF ANIMAL HUSBANDRY.

Experiments with certain phosphorus compounds found in feeding stuffs.—By reference to Bulletins Nos. 238 and 250, it will be seen that the phosphorus of feeding stuffs is practically all in organic forms. It was also learned that the phosphorus of wheat bran is contained mostly in a compound known as phytin that can be removed from the bran by leaching it with water.

Elaborate experiments have been made in comparing rations containing a large proportion of unwashed bran with rations consisting of the same proportion of washed bran.

The data obtained from these experiments involving the use of two animals consistently support the following conclusions. Certain of the facts observed, which, with others, are here briefly summarized, agree with observations made by other investigators.

1. The amount of outgoing phosphorus rose and fell with the quantity supplied in the food, though within narrower limits. When the phosphorus supply was abundant there was a storage of this element in the bodies of the animals, but during prolonged periods in which the supply of phosphorus was deficient there was withdrawn from the body store about ten grams daily in several periods.

2. Through destructive changes, the phosphorus of the phytin and of the unused digested nucleo bodies was reduced to inorganic combinations, and was excreted chiefly in the feces, though to a small extent in the urine.

Further evidence of destructive metabolism of phosphorus compounds is found in the fact that the inorganic phosphates of the milk were from three to five times greater in quantity than the total amount of such compounds in the food. The rise and fall

in the amounts of outgoing phosphorus compounds occurred almost wholly with the inorganic salts found in the excretions. The organic phosphorus bodies of the excretions were but little affected, if at all, by the proportions of phosphorus compounds in the food. Variations in the phosphorus supply appeared not to modify the appropriation of this element by the milk.

3. No relation whatever appears to exist between nitrogen excretion and phosphorus excretion.

4. It is shown without question that the physiological effect of the two rations, due to the withdrawal from the bran of such compounds as were soluble in slightly acidulated water, differed to a marked degree. With the washed bran ration as compared with the one containing the unwashed bran, the following differences were observed.

a. Drier and much firmer feces with the washed bran ration, accompanied by a constipated condition, requiring in some cases the use of a purgative.

b. A marked disturbance of appetite when a sudden change was made from the washed bran ration to the one containing the unwashed bran, indicating some specific physiological influence of the compound or compounds removed from the bran by leaching.

c. A greatly reduced flow of urine following a change from the unwashed bran to the washed bran ration, the reverse taking place when a reverse change was made.

d. An increase in the flow of milk consequent upon the withdrawal from the ration of the phytin and other water-soluble constituents of bran.

e. A reduction, sometimes large, in the percentage of fat in the milk consequent upon the withdrawal from the ration of phytin and other water-soluble constituents of bran.

f. A decreased production of butter-fat during the period the washed bran ration was fed, notwithstanding a somewhat increased flow of milk.

g. The entire cessation of the oestrum period with cow 1 and a temporary disturbance of this period with cow 2.

Whether the physiological effects above indicated were due to phytin wholly or in part to compounds leached out with the phytin

is not fully determined. It is proposed to continue experimental work along this line.

Bang method of controlling tuberculosis.—In 1900 it was found that more than half the animals of the Station herd were affected with tuberculosis. In 1901 the Bang method of controlling tuberculosis was applied to the herd.

The Bang method consists in destroying all animals which show pronounced physical symptoms of the advanced stages of tuberculosis and dividing the remainder on the basis of the tuberculin test. Tuberculin tests are made at intervals to detect any new cases which may develop. The milk from the tuberculous animals is heated sufficiently to destroy any disease germs which may be present. Practically all calves are sound at birth and remain so if proper precautions are taken against subsequent infection.

Within four years the natural increase in our herd amounted to more than the original number of diseased animals and we now have a sound herd which is better in all respects than the one with which we started and we have accomplished this with a minimum of trouble and expense. It would seem that our experience might be a valuable object lesson to the cattle owners of the State.

DEPARTMENT OF BACTERIOLOGY.

Examination of commercial cultures for legumes.—Last season we examined thirty-one packages of cotton which had been inoculated with legume bacteria and did not find a good one.

Reports from experiment stations in Maine, Massachusetts, New York (Cornell), Pennsylvania, Delaware, Virginia, West Virginia, North Carolina, Georgia, Michigan, Wisconsin, Kentucky, Oklahoma and Ontario unite in pronouncing such inoculated cotton of little or no use in inoculating legumes. No experiment station so far as known has obtained satisfactory results from the use of such inoculated cotton.

Further tests of this material would be needless but for the fact that one of the commercial companies is now putting its product upon the market in metal containers, claiming thereby to obviate the objections which were raised against the inoculated cotton packed in parchment paper and tin foil such as was used last season.

We have this season examined fourteen commercial cultures of legume bacteria which were packed in such metal containers and have found them as worthless as the cultures examined last season.

DEPARTMENT OF BOTANY.

Potato spraying expediments.—During the season of 1905 extensive potato spraying experiments were continued along practically the same lines as in 1904. The results appear in Bulletin No. 279. This concludes the fourth year of the ten-year series of potato spraying experiments begun in 1902. Thus far the results have shown spraying to be highly profitable. In 1905, the average gain in thirteen farmers' business experiments, including 167 acres, was 46½ bushels per acre, and the average net profit from spraying $20.04 per acre. Fifty other farmers who made volunteer experiments reported gains averaging 59½ bushels per acre. In the Station ten-year experiment at Geneva five sprayings increased the yield 119⅓ bushels per acre, while three sprayings increased it 107 bushels. In the duplicate of this experiment at Riverhead the gain due to five sprayings was 82 bushels per acre and to three sprayings 31⅓ bushels.

Soda bordeaux and lime bordeaux were again compared as to their efficiency in the prevention of potato blight. In one test rows sprayed four times with lime bordeaux outyielded rows similarly sprayed with soda bordeaux by nine bushels per acre. In another test there was a difference of thirty-five bushels per acre in favor of lime bordeaux. These results agree with those obtained in 1904 and show that for use on potatoes soda bordeaux is not superior to lime bordeaux as has been claimed by some.

The results of experiments with paris green confirm those obtained in similar experiments made in 1904. The conclusion is that potatoes are in no way injured by paris green properly applied, viz: in moderate quantity (one to two pounds per acre) with bordeaux mixture.

In an experiment on the effect of bordeaux mixture made with cold water, potato foliage was in no way injured by being sprayed with bordeaux mixture having a temperature of forty to fifty degrees Fahrenheit.

A currant rust new to America.—In September, 1906, the Station currant plantation was found to be abundantly infested with a leaf-rust fungus (*Cronartium ribicola*) which, with one possible exception, has not been found previously anywhere in America. In Europe it has been known for fifty years and is there widespread. As a currant disease it is not much to be feared. The chief danger from it lies in its effect on white pines. In one of its stages the fungus attacks the trunks and branches of the white pine producing a destructive disease. It would be unfortunate if this disease should become scattered throughout America. Without doubt it is a recent importation from Europe, but just how it came to the Station grounds is not known. In order to stamp out the disease, if possible, every currant and gooseberry bush on the Station grounds has been destroyed. An account of this currant rust appears in Technical Bulletin No. 2.

DEPARTMENT OF CHEMISTRY.

The action of acids on casein when no solution occurs.—This work has for its object to gain information as to whether casein forms an insoluble compound with acids, as in the case of milk curdled by natural souring. The question has been at issue for over fifty years and is of importance as having a practical relation to certain dairy problems. The methods that have been commonly employed in studying this question are found to be unreliable except under special conditions, which have not been appreciated heretofore. A new and reliable method was employed, by which the amount of acid taken up by casein is measured by means of changes in the electrical conductivity of the solutions used. It is shown that casein has the power of taking up acids, but the action appears to be more like physical adsorption than like chemical combination. Casein takes up different amounts of acid according to the time of contact, concentration of acid, etc. It takes up different acids in different amounts characteristic for each acid. The work was carried on with hydrochloric, lactic, acetic and sulphuric acids, of varying degrees of concentration and at several different temperatures.

The accuracy of phenolphthalein as an indicator in measuring the acidity of casein.—Different indicators show different amounts of

acidity possessed by casein and the question is important as to which is most nearly correct. In most of the work done, phenolphthalein is the indicator commonly used. By making use of electrical conductivity measurements, it was possible to determine the acidity with great accuracy, independently of indicators. It was found that the results agree closely with those obtained when phenolphthalein is used, thus confirming the use of this reagent in cases involving the acidity of casein. The matter is one of practical importance in determining the acidity of milk and milk products, in which the acidity of casein is to be determined.

ENTOMOLOGICAL DEPARTMENT.

Commercial miscible oils for treatment of the San Jose scale.— This bulletin contains the details of a number of experiments with proprietary miscible oils to determine their merits for the control of the San Jose scale. These preparations contain more or less mineral oil, which has been combined with an emulsifying agent to facilitate a uniform dilution with water, and are supposed to be safer sprays than clear oils alone for the treatment of orchard trees. The miscible oils that were used were Kil-o-Scale, Scalecide and Surekill, which were tested in varying proportion on 1,369 trees, divided among three orchards. In these tests, applications of miscible oils at the recommended proportions of one part to twenty or twenty-five parts of water failed to give uniform results on scale. The trees receiving these treatments usually showed more or less spotting of the fruit and varying infestation of the new growth. Miscible oils in the proportion of one part of oil to ten or fifteen parts of water, while uniformly more destructive to the scale than the weaker preparations, were usually not quite so effective as the boiled lime-sulphur wash. By these applications large percentages of the scales were destroyed. The treatments were sufficiently effective in this respect to maintain the thriftiness of the trees and to keep the fruit crop fairly clean. On the basis of these results the miscible oils tested should not be used in weaker mixtures than one part to ten or fifteen parts of water.

These sprays are simple to prepare, and have no sediment, and for these reasons are very convenient preparations for the treatment of old trees and small orchards. The cost of the miscible oils in

the proportions of one part to ten or fifteen parts of water makes their use almost prohibitive for commercial orchardists who desire a safe and comparatively cheap oil spray.

Apple and pear mites.—This bulletin is a preliminary treatise upon the Eriophyidae, a group of plant-inhabiting mites of increasing economic importance, in which special attention is given to the species thriving upon the apple and the pear.

In the study of the mites upon these fruits, five species have been recognized, which are *Eriophyes malifoliae* Parr., *Eriophyes pyri* (Pgst.) Nal., *Eriophyres pyri* var. *variolata* Nal., *Phyllocoptes schlechtendali* Nal., and *Epitrimerus pyri* Nal. With the exception of the former, which is new, these species were first recorded from Europe. *Eriophyes pyri* (Pgst.) Nal., known as the leaf blister-mite, is the most abundant species and is responsible for the conspicuous injuries to the foliage of the apple orchards of Ontario, Wayne and Niagara counties.

The leaf blister mite is a small, vermiform, four-legged creature, about one one-hundred-and-twenty-fifth of an inch in length, and is hardly visible to the unaided eye. It hibernates in the buds and with the maturing of the bud scales seeks the unfolding leaves which it punctures, producing light green and redish pimples which develop into galls or blisters of a blackish or reddish brown color, depending on the kind and variety of fruit. Besides the pear and the apple, the mite attacks the serviceberry (*Amelanchier vulgaris* Monch), the common cotoneaster, (*Cotoneaster vulgaris* Lindl.), the white beam tree (*Sorbus aria* Crantz), the European mountain ash (*Sorbus aucuparia* I.), and the wild service tree (*Sorbus torminalis* Crantz).

Nursery stock is commonly infested; and when the mite is abundant, pear foliage is much discolored, and the young trees may be stunted through the destruction of the terminal leaves of the new growth. The appearance of the mite for successive years in the nursery is due to methods of budding. The experiments to control the mite in nurseries are not completed, but it is believed that the pest can be eliminated from the nursery by the selection of buds from clean stock and by the fumigation of budding sticks.

In the experiments upon apple trees, comparative tests have been made with kerosene oil, miscible oil, kerosene emulsion and sulphur

washes. Kerosene emulsion, on account of its safe and efficient qualities, appears to be the most practical remedy for the spraying of apple trees.

DEPARTMENT OF HORTICULTURE.

Apple districts of New York with varieties for each.—Bulletin 275 defines the several distinct horticultural belts in the State, and names the varieties of apples that can be most successfully grown in each. It is also a catalogue of the apples that are grown or have originated in New York. The sorts listed are briefly described, the descriptions having been abbreviated from "The Apples of New York." The bulletin was prepared to serve as a guide to those who are planting apples with a view of preventing the enormous waste occasioned by the continued attempts upon the part of apple growers to grow varieties that are not adapted to the regions in which they are planted. It answers as best this Station can the question so often asked: "What varieties shall I plant?"

The bulletin also considers, in leading up to the main questions as outlined above, the distribution of varieties of apples in which the fact is emphasized that domesticated plants, as well as wild plants, are distributed according to their vital necessities; and that success with any crop depends largely upon its being grown in an environment preeminently well suited to it; thus, distinct classes of farming land, or distinct sets of conditions, are being devoted, more and more, to special crops, a fact well illustrated by varieties of apples in this State.

Another secondary but important fact set forth in the bulletin is that there are groups of apples, the members of which have about the same degree of suitability for a region. The formation and adaptations of these groups of apples are considered somewhat in detail with emphasis on the fact that groups of varieties have adaptations to particular conditions. The groups are founded upon the characters of the fruits and all characters are considered. The number of groups presented is thirty-six, containing 278 varieties.

The factors governing the distribution of groups and varieties of apples is essential to a clear understanding of the matters discussed in the bulletin. These are given as latitude and altitude, temperature, water, soil and air currents; each of these factors is briefly considered.

Varieties of strawberries, with cultural directions.—Bulletin 276 describes the newer varieties of strawberries with some of the standard kinds for comparison. These descriptions are followed by brief cultural directions which answer, to a degree, the many inquiries which come to this Station in regard to the growing of strawberries. In describing the varieties emphasis is put upon the strong and weak features of the new varieties when tested under the soil conditions at this Station; it is pointed out that results are not to be taken as absolute, or even as indicating what might be expected under widely different conditions of environment.

Varieties of raspberries and blackberries, with cultural directions.—Bulletin 278 discusses raspberries and blackberries much as Bulletin 276 discusses strawberries. An interval of eight years elapsed between the publication of this bulletin and any other upon the subject from this Station. This brings the Station's notes, as to the behavior of varieties of the two fruits, up to date. It puts in condensed form information valuable to the small fruit grower.

INSPECTION WORK.

The Station annually receives for analysis from the Commissioner of Agriculture from twelve to fifteen hundred samples of fertilizers and feeding stuffs, requiring upwards of eight thousand single chemical determinations. Some of these determinations are rendered more time-consuming by the fact that occasionally they must serve as testimony in court. These samples are known to the Station authorities only by number. As these analyses are the basis for determining whether fertilizer manufacturers are violating the law as to the quality of their goods, it is necessary to surround this part of our work with all needed precautions as to accuracy. The Station's part in fertilizer inspection is one of the most laborious and expensive duties that it has to perform.

Numerous samples of fertilizers and feeding stuffs are received from manufacturers, dealers and consumers with requests for analyses. These samples are not official in their character and are analyzed only when the circumstances seem to justify the expense involved. The impression seems to prevail on the part of some manufacturers that it is the duty of the Station to make the analyses on which they base their guarantees. No such requirement is even

suggested in the law and it is not possible for the Station to act as the chemist of the fertilizer trade. Dealers often send samples in order to be assured that their goods are in accordance with the guaranteed requirements. As to these samples, it should be said that there is an annual inspection of the various brands sold in the State and it is not feasible to be continually repeating analyses of brands that are examined officially by the Commissioner of Agriculture. Samples from consumers are treated according to circumstances. In a large majority of cases they do not involve matters of sufficient importance to render the analyses advisable. In many cases, also, analyses are not necessary in order to give to the interested parties the information that is desired.

PUBLICATIONS ISSUED DURING 1906.

BULLETINS.

No. 275. April. Apple districts of New York with varieties for each. U. P. HEDRICK, N. O. BOOTH and O. M. TAYLOR. Pages 61.

No. 276. April. Varieties of strawberries and cultural directions. O. M. TAYLOR. Pages 18.
Popular edition. Pages 8.

No. 277. April. The Bang method of controlling tuberculosis, with an illustration of its application. H. A. HARDING and GEORGE A. SMITH, of the New York Agricultural Experiment Station, and V. A. MOORE, of the New York State Veterinary College. Pages 29.
Popular edition. Pages 8.

No. 278. May. Varieties of raspberries and blackberries, with cultural directions. O. M. TAYLOR. Pages 41.
Popular edition. Pages 12.

No. 279. May. Potato spraying experiments in 1905. F. C. STEWART, H. J. EUSTACE and F. A. SIRRINE. Pages 77, plates 5, map 1.
Popular edition. Pages 16.

No. 280. August. Inspection of feeding stuffs. Pages 28.

No. 281. December. Commercial miscible oils for treatment of the San José scale. P. J. PARROTT, H. E. HODGKISS and F. A. SIRRINE. Pages 10.
Popular edition. Pages 8.

No. 282. December. Quality of commercial cultures for legumes in 1906. M. J. PRUCHA and H. A. HARDING. Pages 8.
Popular edition. Pages 4.

No. 283. December. The apple and pear mites. P. J. PARROTT, H. E. HODGKISS and W. J. SCHOENE. Pages 50, plates 8.
Popular edition. Pages 8.

No. 284. December. Director's report for 1906. W. H. JORDAN. Pages 24.

TECHNICAL BULLETINS.

It has seemed best to make a slight change in the numbering of bulletins of this Station; and to issue, in future, a series to include discussions of technical and scientific phases of our work. Those issued during 1906 are as follows:

No. 1. November. A study of the metabolism and physiological effects of certain phosphorus compounds with milch cows. W. H. JORDAN, E. B. HART and A. J. PATTEN. Pages 59.

No. 2. December. An outbreak of the European currant rust. F. C. STEWART. Pages 14, plates 3.

No. 3. December. I. The action of dilute acids upon casein when no soluble compounds are formed. II. The hydrolysis of the sodium salts of casein. L. L. VAN SLYKE and D. D. VAN SLYKE. Pages 88, figs. 17.

Several bulletins previously issued are of the same general character. These are:

No. 214. A study of some of the salts formed by casein and paracasein with acids; their relations to American cheddar cheese.

No. 215. Methods for the estimation of the proteolytic compounds contained in cheese and milk.

No. 219. Some of the compounds present in American cheddar cheese.

No. 231. The relation of carbon dioxide to proteolysis in the ripening of cheddar cheese.

No. 233. Renet enzyme as a factor in cheese ripening.

No. 236. Conditions affecting chemical changes in cheese ripening.

No. 237. The role of the lactic-acid bacteria in the manufacture and in the early stages of ripening of cheddar cheese.

No. 238. The status of phosphorus in certain food materials and animal by-products, with special reference to inorganic forms.

No. 250. The nature of the principal phosphorus compound in wheat bran.

No. 256. Seed selection according to specific gravity.

No. 261. Some of the relations of casein and paracasein to bases and acids, and their application to cheddar cheese.

No. 265. I. Plant-food constituents used by bearing fruit trees. II. Tabulated analyses showing amounts of plant-food constituents in fruits, vegetables, etc.

CIRCULARS.

No. 6, new series, April 5. The renovation of worn-out orchards. U. P. HEDRICK. Pages 4.

No. 7, new series, April 25. The "King System" of stable ventilation. W. H. JORDAN. Pages 4, figs. 5.

W. H. JORDAN, *Director.*

New York Agricultural Experiment Station.
Geneva, N. Y., Dec. 31, 1906.

REPORT

OF THE

Department of Animal Husbandry.

W. H. Jordan, *Director.*

W. P. Wheeler, *First Assistant.*

G. A. Smith, *Dairy Expert.*

H. A. Harding, *Bacteriologist.*

E. B. Hart, *Associate Chemist.*

A. J. Patten, *Assistant Chemist.*

TABLE OF CONTENTS.

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY.

THE BANG METHOD OF CONTROLLING TUBERCULOSIS, WITH AN ILLUSTRATION OF ITS APPLICATION.*

H. A. HARDING and GEO. A. SMITH, of the New York Agricultural Experimental Station, and V. A. MOORE, of the New York State Veterinary College.

SUMMARY.

1. Tuberculosis is one of the most important diseases of cattle.

2. The Bang method of handling herds affected with this disease has been tried with success in various countries. This method is especially adapted to herds of valuable animals.

3. The method consists in isolating the reacting animals in order to stop the spread of the disease and holding them for breeding purposes.

4. Calves of tuberculous cows are rarely if ever tuberculous at birth. They should be immediately separated from the dam and fed on the milk of healthy cows or on milk which has been properly pasteurized.

5. The milk of tuberculous cows is safe after it has been pasteurized at 185° F. (85° C.).

6. More than one-half of the herd of the New York Agricultural Experiment Station was found to be tuberculous in December, 1900.

7. Quarters were prepared and the application of the Bang method begun in October, 1901, with a total of thirty animals, thirteen of which were healthy and seventeen tuberculous.

8. During four years this herd produced twenty-three desirable heifer calves, approximately one-half coming from the tuberculous animals, and in November, 1905, it contained thirty healthy animals.

* A reprint of Bulletin No. 277.

INTRODUCTION.

During the last decade the progress which the cattle owners of this State have made in the control of tuberculosis in their herds has been slight and this progress has been in comparatively few herds. While exact data are lacking it is probable that there is more tuberculosis in the herds of the State to-day than there was ten years ago.[1]

As long as tuberculosis was considered purely as a public health problem and was handled with little regard for the interests of the cattle owner, there was often a disinclination on his part to face the facts. With a better knowledge of the nature of the disease the more progressive breeders and dairymen are coming to feel that tuberculosis, like any other destructive disease of cattle, is an unprofitable adjunct to the business. Accordingly they are beginning to inquire into the various methods of freeing their herds from this pest.

The herd of the New York Agricultural Eperiment Station was accidentally infected through the purchase of apparently sound cows and before the disease was detected more than one-half of the herd had become tuberculous. From this undesirable condition the herd has been transformed into a sound one within four years and it is believed that a statement of the conditions encountered and means employed to eradicate the disease will be especially helpful to the dairymen at this time.

In this work we can lay little claim to originality since we have followed the method recommended by Dr. Bang[2] of Copenhagen. Considering the uniform success which this method has met with in the various countries in which it has been employed it seems strange that it has not been more widely used in America. It is hoped that this presentation of the method and of the way in which it was successfully employed in the Station herd may stimulate its introduction into the herds of the State.

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[1] In the report of a Special Committee of the Assembly on Tuberculosis presented February 1, 1900, the tuberculosis among cows in New York State was estimated at not to exceed 6 to 7 per cent.

[2] Bang B. The struggle with tuberculosis in Denmark. *The Veterinarian*, **68**:688. 1895.

Bang B. Tuberculosis of cattle. Appendix. Bulletin 75 of the Department of Agriculture of the State of Pennsylvania. 1901.

ACKNOWLEDGMENT.

The official heads of the two coöperating institutions, Dr. W. H. Jordan of this Station and Dr. James Law of the New York State Veterinary College, have taken a keen and inspiring interest in the work here reported and we desire to record our appreciation of the value of their suggestions and advice in connection with the same.

THE NATURE OF TUBERCULOSIS.

Tuberculosis is a specific infectious disease. It is specific because it is produced by a single cause, the tubercle bacillus; it is infectious because this organism gets into the animal body and multiplies there. It affects the animal by growing into the tissues and actually destroying the organs of the body that are necessary to the life of the individual, such as the liver, lungs and other vital parts. Although the course of the disease is often very chronic, it possesses all of the characters that determine an infectious malady. Because of its insiduous nature and slow development, cattle owners are very liable to ignore the essential conditions in its dissemination and thereby often expose their herds to this most destructive of cattle diseases.

The two most important facts to know about an infectious disease are, (1) how the micro-organisms that cause it escape from the diseased animal and (2) how the sound animals become infected. The answers to these questions relative to bovine tuberculosis are for the greater part not difficult.

The tubercle bacteria escape from a tuberculous animal when the tissues they have destroyed are being discharged from the body. If the lungs are affected the dead particles of tissue, laden with tubercle bacilli, escape into the bronchial tubes and after being coughed up into the mouth they leave the body with the saliva. In these cases the tubercle bacteria can be found in the saliva that is left on the surface of the water in watering troughs or on the bottom of the mangers.[3] If the tissues attacked happen to be glands in the walls of the intestine the dead particles of

[3] Ravenel, M. P. The dissemination of tubercle baciclli by cows in coughing a possible source of contagion. University (Penn.) Medical Magazine, November, 1900.

tissue escape with the intestinal contents. If the disease becomes localized in the udder then the bacteria pass out with the milk. In cases where the lesions are restricted to subcutaneous glands or tissues, abscesses may be formed and the dead tissues laden with tubercle bacteria may escape through an opening in the skin. If the disease is localized the tubercle bacteria are liable occasionally to grow or eat their way into a blood vessel when they may be carried in the blood to any or all parts of the body and temporarily escape into the milk, intestinal contents or sputa.

When the bacteria have escaped from infected individuals into mangers, watering troughs, or on to the grass in pastures, they are readily taken up by healthy cattle that drink, feed or graze after diseased animals. In case the bacteria are escaping with the milk, calves and swine fed with it are very liable to become infected.

The period of incubation, that is the time between the entrance of the bacteria into the body and the appearance of the fresh tissue changes (tubercles) is variable. There is good evidence to show that it may be very short in some cases and very long in others. It is safe to assert that it may vary from a few days or weeks to as many months. Tuberculin does not give a reaction during the period of incubation. This condition requires for safety that animals that do not react to tuberculin in herds where the disease exists and where they may have become infected must be tested several months later to be sure that they were not infected at the time the first test was made.

The duration of the disease varies quite as much as the period of incubation. Tuberculosis may run a rapidly fatal course, the affected animal dying in a few months.[4] As a rule, however, the duration of the disease is much longer. The tuberculous tissue may become encapsulated and the disease remain stationary for a long time[5] and in some cases recovery may take place. In an experi-

[4] The cow Jane is an illustration of this point. She became diseased during 1901 and first reacted in October, 1901. She failed rapidly and was killed in June, 1902. The autopsy showed that her liver was badly diseased.

[5] This is well illustrated by Chloe and Kate. They were tuberculous when tested as two-year-olds in 1900 but when killed and examined in 1905 both were so slightly diseased that their carcasses would both pass a Federal meat inspection examination. During these five years Chloe gave a positive reaction to tuberculin at eight different tests while Kate gave a positive reaction five times and failed to do so at three tests.

ment by Moore,[6] twelve of seventeen cows that reacted in April failed to react in October. These were all destroyed. They all contained tubercular lesions of a chronic type. They all contained living tubercle bacteria as proven by guinea pig inoculations. It is known that the lesions may remain in a chronic encapsulated condition for three years and the tubercle bacteria still be alive.[7] In the cases of arrested tuberculosis the disease does not spread in the body, but so long as the tubercle bacilli remain alive it is possible that the disease may start up at any time for there is very little, if any, immunity established against a subsequent attack by the development and encapsulation of the primary lesion. One of us (Moore) has the records of over fifty cows that have reacted but failed on subsequent tests, from six to eighteen months thereafter, to react but still later did react. Whether the late reaction was caused by a reinfection or by renewed activity of an encapsulated, arrested lesion is not determined, but the fact that, to all appearance and methods of diagnosis in a living animal, the lesions in these animals were healing or healed and that later they responded to the test suggests that the first attack did not impart immunity.

As a rule the tubercular changes occur in one or more of the following organs: (1) In the lungs or lymphatic glands draining them, (2) in the lymphatic glands about the head, (3) in the intestines and mesenteric glands, (4) in the glands of the liver or the liver itself and (5) in the generative organs and udder. It frequently happens that the pleura or the peritoneum is thickly sprinkled with tubercular nodules. The extent of the disease that may exist and have the animals appear to be in perfect health depends upon the location of the lesions. Frequently large masses of tubercular deposits are found in apparently healthy animals. As a rule these are not in vital organs. Again, cattle run down rapidly and may die of the disease before the lesions attain great size because they are in and destroying an organ that is very essential to the life of the individual.

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[6] Moore, V. A. A report on bovine tuberculosis. N. Y. Dept. Agr. Annual Report, 1903.

[7] Millie D. gave a reaction in October, 1901, and in June, 1902. She failed to react at six subsequent tests beginning with December, 1902. She contained living germs of tuberculosis in 1905, page 55.

The possible long period of incubation and duration of the disease, the frequent encapsulated condition of the lesions and the absence of immunity from a natural infection are important factors to be considered in the application of any method for its elimination or control.

THE BANG METHOD.

The Bang method for handling tuberculosis is simply the procedure recommended and carried into effect in Denmark by Prof. B. Bang of the Copenhagen Veterinary College.[8] The object of this method is to replenish a tuberculous herd with as little loss as possible. It requires that all animals that show physical symptoms of the disease shall be destroyed. Those which give a tuberculin reaction but which exhibit no evidence on physical examination of being tuberculous are isolated. They are kept for breeding purposes. The reacting animals are carefully watched and if any of them develop obvious symptoms of the disease they are slaughtered.

The method as originally proposed has been modified from time to time in accord with increased knowledge of the disease and the conditions under which it exists. The success of the method rests in the fact that it conforms to the chronic nature of the disease and its tendency to become arrested. The large percentage [9](35.4%) of dairy cows in Denmark that reacted to tuberculin suggested the importance of replenishing the herds with healthy cows before the total destruction of the reacting ones. The method is summarized in the following statements.

1. A herd is tested with tuberculin. The animals that are in a bad condition are slaughtered. The reacting animals that show no physical evidence of the disease are isolated. They are kept for breeding purposes.

2. The offspring from the reacting cows are promptly removed from their dams and fed milk from non-reacting cows, or the pasteurized (heated to a temperature of 85° C. (185° F.)) milk

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[8] Bang, B. The struggle with tuberculosis in Denmark. *The Veterinarian*, 68:688, 1895.

Bang, B. Tuberculosis of cattle. Penn. Dept. of Agr., Appendix Bul. 75, 1901.

[9] *Loc. cit.*

from the reacting ones. The milk of the isolated cows after pasteurization is also used for human food.

3. If any of the isolated cattle give evidence of the disease advancing, such as enlarged glands or emaciation, they are slaughtered.

4. The non-reacting animals are tested from time to time and if any individuals react they are placed with the isolated ones.

5. The calves that are raised from the reacting cows and which fail to react to tuberculin[10] are placed in the sound herd.

As the sound herd is replenished the isolated cattle may be fattened and killed, under proper inspection, for beef. The laws of nearly, if not all, countries permit the use of meat of tuberculous animals for food when the disease is localized.[11] In this way

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[10] It is important to test, with tuberculin, calves that have been born of tuberculous dams and raised on pasteurized milk of tuberculous cows for the reason that it is possible through inadvertent accidents that some of them have become infected. In our observations in various herds from one to four per cent. of the calves brought up under these condition have reacted to tuberculin at six months of age. No such cases appeared among the calves of the Experiment Station herd during the progress of this work.

[11] In the disposition of tuberculous cattle, practice has established the feasibility and safety of using the flesh for food when the disease is localized. The United States Meat Inspection Regulations permit the carcasses of tuberculous animals to pass and to be sold as sound when the lesions are restricted in their distribution as follows:

"(1) The carcasses may be passed when the lesions are limited to one group of lymphatic glands or one other gland.

"(2) The carcasses may be passed when the lesions are limited to two groups of visceral lymphatic glands in either the thoracic or abdominal cavity.

"(3) The carcass may be passed when the lesions are limited to two visceral organs (other than lymphatic glands) in the thoracic or the abdominal cavity, provided the lesions are slight, calcified, and encapsulated.

"(4) The carcass may be passed when the lesions are limited to one group of visceral lymphatic glands and one other organ in the thoracic or abdominal cavity, provided the lesions in the affected organs are slight.

"(5) The carcass may be passed when the lesions are confined to two groups of visceral lymphatic glands and one other organ in the thoracic or abdominal cavity, provided the lesions are slight, calcified, and encapsulated.

"(6) The carcass may be passed when the lesions are confined to the lungs, the cervical lymphatic glands, and one group of the visceral lymphatic glands of the thoracic cavity, provided the affection is slight and the lesions are calcified and encapsulated." U. S. Dept. Agric.: B. A. I. Order 125.

the people of Denmark have been able to greatly reduce the very high percentage of tuberculous cattle and at the same time minimize the loss they formerly sustained by the frequent death of diseased animals.

Among the first, if not the first, to put the Bang method to a test in this country was the Wisconsin Agricultural Experiment Station.[11a] They began in January, 1896, with 16 reacting animals and 18 healthy ones. In February, 1899, they had 27 healthy animals, all the progeny of the group of tuberculous cattle. Russell pointed out at that time that the method afforded a practical and often a most desirable way to replace a tuberculous herd.

The Bang method has been applied with great success in Hungary where the reports show that many highly infected herds have been freed of the disease in from four to six years. In Norway and Sweden the results have been equally good. Prof. Regner[12] states that the percentage of reacting animals among 36,149 cattle was, at the beginning of the application of this method, 33.6 per cent. After a period of from two to nine years it has been reduced to 4.7 per cent. It is not the purpose of the method to return to the sound herd animals that have reacted but which after a period of one or more years fail to react. Experience has shown that a variable number of reacting animals will stop reacting in from six to eighteen months and remain apparently in a sound condition. The present interpretation of this phenomenon is that the disease has been arrested, but because the time limits of the life of tubercle bacteria residing in encapsuled lesions is not known, it cannot be considered safe to return these animals to the healthy herd.

This method has the redeeming feature that it requires the elimination of cattle that have no real value because of the advanced stage of the disease but enables the owner to obtain the actual worth of the others. It has been possible because of the great value of tuberculin in detecting the infected animals that still appeared to be in perfect health.

[11a] Russell, H. L. The history of a tuberculous herd of cows. Wis. Agr. Exp. Station, Bul. 78, 1899.

[12] Regner, Gustav.—The suppression of tuberculosis among domesticated animals. Eighth International Veterinary Congress. Budapest, Sept., 1905.

TUBERCULIN.

Tuberculin is the concentrated liquid, usually glycerinated bouillon, on which the tubercle bacteria have grown until the products resulting from their multiplication have become imparted to the medium in sufficient quantity to inhibit their further development. It is not definitely determined just what these products are or just how they are elaborated.

In the preparation of tuberculin the saturated cultures are heated to destroy the tubercle bacteria, filtered through the Pasteur or Berkefelt filter to remove all the bacteria, and the filtrate condensed over a water bath. To the properly concentrated fluid a little carbolic acid is added to preserve it. It is evident, therefore, that tuberculin cannot produce tuberculosis, as the tubercle bacteria have been first killed by heat and then removed by filtration. It has never been known to produce any bad effect upon either tubercular cattle or healthly ones. It is the most accurate test for the detection of disease that is known to medical science.

APPLICATION OF TUBERCULIN.

In applying the tuberculin it is important to observe the following:

1. The normal temperature of the animal to be tested must be determined. It is recommended that it be taken hourly or every two hours for the day proceeding the test. In practice veterinarians usually take the temperature but once or twice before injecting the tubeculin.

2. The tuberculin is injected subcutaneously in the side of the neck. Care should be taken that the syringe is sterile and the site of injection should be disinfected. The size of the dose depends upon the preparation of the tuberculin, that is, the degree of its concentration.

3. Beginning 6 or 8 hours after injection the temperature should be taken hourly, or at least every two hours for fully three-fourths of a day.

4. During the time of testing the cattle should be kept quiet and free from all exposures and fed normally.

5. In case of reaction there should be a rise of at least 1.5° F. above the normal individual temperature as determined on the pre-

ceding day. In order to avoid error several initial temperatures should be taken. In practice, veterinarians usually take only a single temperature to determine if the cow is not suffering from a fever, due perhaps to other causes. The reaction in such cases is determined by the temperature curve. This procedure is liable to give erroneous results. The elevation of temperature should come on gradually, remaining practically at its maximum for a few hours and gradually subside. Erratic elevations of short duration are to be excluded. In cases of doubt the animal should be retested.

6. Animals advanced in pregnancy and those known to be suffering from any disease should be excluded. All methods of treatment, including exposure to cold or kind of food or drink which would tend to modify the temperature should be avoided. Animals in which tuberculosis is far advanced are said sometimes to fail to react.[13]

7. The dose of tuberculin should vary to correspond to the weight of the animal. The dose for an adult cow of average weight is 0.25 cc. of the concentrated Koch tuberculin. This should be diluted to 2 cc. with a weak (1 per ct.) solution of carbolic acid before injecting. The tuberculin prepared at the New York State Veterinary College is ready to inject when it is sent out. In cases where a second test is made within a few days the quantity of tuberculin injected should be larger than for the first test.

The interpretation of the temperature record requires care. If, however, all conditions pertaining to the protection of the animal have been fulfilled, the temperature curve mentioned is a very sure indication that the animal is suffering from an active, although it may be a very small, tubercular growth. If there is no reaction the correct interpretation is more difficult. In this case there are three conditions which must be taken into account, namely: (1) If the animal is extensively diseased it may not react. In this case the physical condition would show that the animal was at least not healthy. (2) If the test was made during the period of incuba-

[13] Such a case has not come under our immediate observation. Aurora gave a decided reaction when her body was literally filled with tuberculous tissues. See page 47.

tion there would be no reaction although the disease may soon develop. To overcome this danger a subsequent test should be made in from three to six months. (3) It is known that cows that have reacted, may, because of the arrest of the disease, fail to react subsequently but later the disease may start up again, when the animal would react. We have records of several cases of this kind. Great care must be exercised, therefore, in the interpretation of negative results, especially in tests made in herds where tuberculosis exists, and where it is possible that the animals failing to react have been infected.

COMPOSITION OF THE STATION HERD.

In December, 1900, the Station herd contained seventeen mature cows and eleven heifers ranging in age from eight months to two years. Eight of the cows were full-blooded Jerseys and the remainder, with a single exception, were Jersey grades. Two of the cows had been raised on the farm, while the remaining fifteen had been purchased in 1898–1899. The purchased animals represented nine herds in the central part of the State.

Care had been exercised in purchasing to procure desirable animals from all points of view. They were not bought, however, subject to the tuberculin test.[14]

The young stock had all been raised on the farm and represented the most promising heifers of the two preceding seasons.

FINDING TUBERCULOSIS IN THE HERD.

In the fall of 1900, Cow No. 8, which had been purchased by the Station in 1898, steadily lost flesh. She was given a physical examination on Nov. 27 by a local veterinarian who pronounced her tuberculous. She was promptly killed and found to be suffering from the disease in its advanced stage.[15] As in many other

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[14] Soon after the arrival of the new animals abortion became troublesome and continued for some years. This trouble seriously interfered with our later attempts at renewing the cows through their offspring as not only did many of the old cows lose a calf but for some years practically every heifer lost one calf and in one case two in succession.

[15] The autopsy notes show the following distribution of lesions:

"Right sub-maxillary lymph gland contained pus. Caudal mediastinal lymph gland enlarged to eight inches in length and tuberculous. Lungs

herds, the breaking down of a tuberculous animal was the first intimation that the disease had gained a foothold.

Naturally the first question that arose was as to the state of health of the remaining animals. But two methods of determining their condition were available; the physical examination and the tuberculin test. Physical examination is a general method which is commonly applied to the diagnosis of many animal diseases. For the reason that dairymen are familiar with it and constantly using it in handling their cattle many of them are inclined to place more confidence in its results than in a method with which they have had practically no experience. In detecting the early stages of tuberculosis in cattle, physical examination is of little assistance because at this stage the disease is ordinarily located in the deep-lying glands entirely out of the range of observation. It is only when the disease has progressed to the point where considerable lung tissue is involved or some of the superficial glands are considerably enlarged that the tubercular condition may be readily detected.

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normal except for a tubercular area in each caudal lobe, the larger being on the left side. Heart and pleurae were normal. Many tubercles ¼ to ½ inch in diameter scattered over the peritoneum. Capsule of the liver was dotted over with tubercles but the liver itself appeared to be normal. Uterus was infiltrated with tubercular tissue. The ovaries contained caseated masses, probably tubercular, in the center of each. The udder, which was considerably enlarged at the date of killing, was removed to the laboratory. Here it was cut into thin slices and carefully observed but no tubercles were found."

November 30, three rabbits were injected with material from Cow No. 8. One received a portion of the milk from the udder, a second received pus from an ovary while the third was injected with water in which two small tubercles from the uterus had been crushed.

February 12 one of the rabbits died and the other two were killed. The autopsies in all cases showed well marked tuberculosis. The lungs and diaphragm of all three were affected, in one case to such an extent as to make breathing difficult. In two cases the peritoneum was covered with modules while in the third case where the injecting needle had not reached the abdominal cavity there was a large fibrous mass with pus at its center. One or both kidneys in each of the rabbits contained tubercles. These results made it plain that not only was cow No. 8 suffering from tuberculosis in an advanced stage but what was more alarming her milk contained virulent tubercle bacilli. This latter fact was especially interesting in view of the failure to find any tubercular lesions in the tissue of the udder even when it was cut into thin strips and carefully examined both by sight and touch.

The tuberculin test, on the other hand, responds to the presence of a single active tubercular nodule as readily as to a number, but it unfortunately does not give any measure of the extent of the disease. From these facts it would seem plain that when dealing with the early stages of this disease the tuberculin is the more efficient guide. In our own case only one animal was considered suspicious on physical examination while a tuberculin test of the herd, on Dec. 5-6, 1900, gave a positive reaction with eight mature cows and seven of the young cattle out of a total of twenty-eight.[16] As will be seen the subsequent results proved the reliability of the test.

CONSIDERING THE SITUATION.

A sound herd was a necessity in order that the experimental work of the Station might be properly conducted. With more than one-half of our cattle diseased, the question was as to the best way to obtain a sound herd. The only way in which we could do this was either by disposing of the diseased animals and buying sound ones or by following the Bang method which has already been described.

The common method of disposing of reacting animals was by slaughter and burial. Where this wasteful method is not followed but the cattle in the earlier stages of the disease are fattened and sold for beef, subject to Federal inspection, only the beef value of a part of the animals could be obtained. In this herd all of the animals represented good breeding and a part of them were registered stock. By following the slaughter method all of the advantages of this breeding would be lost. Again it would be necessary

[16] The stable in which these animals were kept was a large basement with two rows of stanchions facing each other but with a wide driveway extending down the center. While the cattle were let out daily, in suitable weather, into the paddock or pasture they were returned each night regularly to their own stanchions. Accordingly the location of the diseased animals in the barn is of interest. Cow No. 8 had stood midway in a row of fifteen mature animals. The first four cows standing immediately to her right all reacted and the first three and the fifth cow standing to her left also reacted. These eight were the only mature cows which responded to this tuberculin test. The two oldest heifers were at the extreme right of the line of cows and did not react. The remainder of the young cattle were at the opposite side of the barn and arranged according to age. The two oldest at the end of the line did not react but the seven younger heifers ranging in age from eight to seventeen months all reacted.

to buy cows to replace the diseased ones, and even if bought subject to the tuberculin test there was a strong probability that they would not all be sound animals.[17]

It was accordingly decided to apply the Bang method as soon as suitable quarters could be provided for the two herds. A substantial addition to our stables was then being built and was ready for use in March, 1901.

PARTIAL SEPARATION OF THE HERD.

Ten cows and six calves were transferred to this new stable in March, 1901. Because of the time which had elapsed since the test, cows were selected from those which had not reacted at the previous test and included only the two oldest non-reacting heifers. Five of the calves had been dropped since the previous test and had been raised on pasteurized milk.[18]

The remaining heifer, Nellie, was so young at the time of the first test that she was not tested at that time.

While this division of the herd was made as the result of the test it should not be forgotten that this test had been made some three months previous to the date of separation. During this interval the cattle had all been kept in the same stable or had occupied the same paddock.

CHANGES IN THE HERD.

During the interval between the discovery of tuberculosis in November, 1900, and the separation of the sound and reacting animals into two herds in March, 1901, five cows passed out of the herd. Two of the reacting cows died with milk fever and a third became so lame with a tuberculous joint that she was killed. One reacting and one sound cow were sold for beef. March 25, 1901, we received a heifer calf Carey in exchange for bull calves.

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[17] These failures to detect the disease are largely due to the period of incubation. (See page 30.) This is well illustrated by a cow purchased in 1904 from a herd containing tuberculosis. A few days after her purchase she did not react to the tuberculin test. She remained in our sound herd for six months and at that time gave a good reaction. An autopsy made six months later showed two small tubercles in the glands of the neck and one small one in the lung.

[18] The milk was heated to 85°C. (185°F.) in a continuous pasteurizer such as is commonly used in connection with butter making.

She was added to the sound herd. As this calf became a part of our herd before the real beginning of our work of breeding tuberculosis it has been thought best to include her in the enumeration[19] throughout.

During the years in which this work was in progress nine cows and three bull calves have been purchased. As these animals have not been in the herd for the full time and as they were all purchased as sound animals (although as has been noted, some became tubercular) it has seemed best that neither these cows nor their offspring should be considered in giving the history of our original herd.

BANG METHOD APPLIED.

Test of October, 1901.—After an interval of eleven months the entire herd was again tested, October 11–12, 1901. At this test all the animals remaining in the old stable reacted, with the exception of Kittie, one of the heifers which had given a reaction at the previous test. Kate and Tess, two heifers which had not reacted in 1900, now gave an undoubted reaction.

In the new stable the calf, Nellie, which had not been tested the previous year, as well as the cow, Jane, which stood beside it, reacted. Two other cows in this stable, Millie D. and Lady of Loch, also gave a reaction.

During the year five cows had developed the disease beside the calf, Nellie, which had not been previously tested. This observation is of interest as it gives an idea of the rate at which the disease was spreading through the herd.

Separation of the herd on the basis of the test.—The calf and the three cows in the new stable which had given a reaction with the tuberculin were now placed with the unsound herd. This left seven cows and six calves, or a total of thirteen, which had not given a reaction to the tuberculin test out of a total of thirty.

This was the condition of our herd when, in October, 1901, we started to replace the diseased animals with sound ones by means of healthy heifer calves raised from the two herds.

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[19] She later produced one heifer and two bull calves and her heifer dropped a bull calf. If any one should take exceptions to this manner of treating the matter they have only to deduct one from the list of sound animals at the beginning and two from the list at the close to obtain the corrected number.

In accomplishing this end we did not hesitate to reject any healthy cow or calf when for any reason it did not give promise of being a profitable and desirable dairy animal. Belle of Spring Brook was sold for beef before the end of the year because of sterility. Pet was also sold for beef because she was not a sufficiently profitable animal to be desirable for breeding purposes. For the same reason five of the reacting animals were disposed of at the same time.

DISINFECTION OF THE STABLES.

If the herd was to be kept healthy it was necessary that any germs of tuberculosis which may have been scattered in the new stable by the tuberculous animals be destroyed. Accordingly the new stable was first cleaned and swept and the floor allowed to dry. This latter precaution was taken in order to insure good penetration of the disinfecting solutions.

When in proper condition the entire interior of the stable, with all the utensils in use there, was sprayed with a solution of corrosive sublimate, one part to one thousand parts of water.[20]

The disinfecting solution was applied in a fine spray with the hope of hitting every part of the surface, but the application was continued until the surface was soaked so that there might be enough material at hand to penetrate to considerable depth in porous places.

When the application of corrosive sublimate was dry the walls and stanchions were treated to a coat of oil or paint, depending upon the way in which they were originally finished.

In order to reduce the danger of reinfection and consequent aggravation of the disease, as well as to decrease the danger of the infected material being carried into the new stable, the old stable was also disinfected.

After a thorough sweeping down and cleaning out, this stable was also carefully sprayed with corrosive sublimate. In this stable the disinfection was followed by a coat of whitewash. We attempted to apply this with a hand spray pump, thinking that in

[20] This strength is most conveniently obtained by the use of compressed tablets which may be obtained at any drug store; or 2¼ ounces of the powdered corrosive sublimate to fifteen gallons of water will give a solution of the desired strength.

this way we could more effectually fill the small crevices. It did not seem practical in this way to handle a whitewash of sufficient body to give satisfaction. With a power sprayer it is quite possible that the result might be better. The caustic effect of the freshly-prepared whitewash is such as to destroy the germs with which it comes in contact. While it is a good disinfectant, as far as it reaches, its mechanical form is such that it does not penetrate into all of the crevices where it is desirable that a disinfectant should go. For this reason we had made the previous application of corrosive sublimate.

PLAN FOR HANDLING THE HERDS.

The stables having thus been rendered as free from tubercle bacilli as it was practical to get them, and all animals which had given evidence of tuberculosis having been taken out of the new stable, the task of producing a sound herd of equal size was begun.

As has been explained, the plan was to prevent the disease from attacking any more of the sound animals if possible and to relv upon the healthy calves to rebuild the herd. In order to accomplish this certain precautions seemed necessary.

In the healthy herd.— The animals were kept from all contact with the diseased ones both in the stable and in the pasture. The food and water supply was carefully guarded from infection by the germs of tuberculosis. A satisfactory water supply at the barn is difficult to arrange. A single diseased animal using the common source of supply is liable to contaminate it. For a year we used individual pails but found it a troublesome method.

No barn utensils of any kind were taken from the stable of the infected cows into that of the healthy herd without first being so treated as to remove the danger of carrying disease.

So far as was practical the two herds were looked after by different men. When it became necessary for a single attendant to work with both herds the use of a separate pair of shoes and outer garments in the two barns was required.

The ventilation of the barn was adjusted with the aim of supplying an abundance of fresh air, and the exercise and food of the animals was arranged with the idea of keeping them in vigorous condition rather than of forcing a large production.

The cattle were tested with tuberculin twice each year in order that any cases of disease which might develop might be detected before it had spread to other animals. May and November were preferred for making the test, but the exact time was determined partly by convenience and partly by a desire to avoid testing cows in an advanced state of pregnancy. Cows were usually omitted from the test when within six weeks of the date when they were due to calve. Strictly speaking, no purchased animal should have been admitted to the sound herd until it had been tested with tuberculin and failed to react. For lack of a convenient place for holding such animals in quarantine they were usually placed in the sound herd and tested within a few weeks. In a number of cases they were found to be tuberculous, and accordingly for a time had exposed the herd to serious danger.

Animals reacting to tuberculin were at once removed to the other herd and were considered as tuberculous after that time, no matter what reaction they gave later. There may be exceptions to the rule that an animal once tuberculous always remains so, but in the present state of our knowledge the only safe course lies in observing it.

In the diseased herd.— The cattle were given the same care as to their feed and general condition that was bestowed upon the sound herd. It was often a matter of comment by persons who inspected both herds at different times during the progress of the work of the diseased herd, so far as physical appearance went, was fully the equal of the sound one.

The cattle were tested with tuberculin at least once a year and in most cases twice. This was done for the purpose of scientific study rather than with any idea of returning them to the sound herd.

Whenever any of the animals were found to be unsatisfactory for breeding purposes and were in good condition they were sold for beef.

When any of the animals began to show signs of breaking down due to the disease they were killed and buried. This was done because their usefulness was about at an end and to have kept them longer would have needlessly exposed their companions and have increased the danger to the sound herd. For this reason Cows No. 4 and No. 10 were killed in November, 1901.

A few of the tuberculous cows were killed in order to clear up certain questions which arose in connection with the work.

The milk from the tuberculous herd was handled in entirely separate utensils and was passed through a continuous pasteurizer at 85°C. (185°F.). It was then considered harmless[21] and the skim milk was fed to the calves and the cream made into butter. During a considerable period the milk was used, after being thus pasteurized, for the local milk trade with entire satisfaction.

The calves from the tuberculous cows were at once removed to the sound herd and were fed on the full milk of the sound cows and later upon the mixed, pasteurized, skim milk from both herds.

CHANGES INDUCED BY THE BURNING OF THE BARNS.

In May, 1902, the Station barns were destroyed by fire. This fire started in the upper portion of the new stable and spread so rapidly that three calves and one two year old heifer from the sound herd were destroyed. In the confusion attending the removal of the cattle from the stables both herds were allowed to mingle and remain together for a few hours. They were, however, promptly separated and placed in temporary quarters.

Up to this time we had accurate records of the food consumed and milk produced by each animal. From this data we hoped to obtain some information concerning the relative profit of keeping tuberculous and sound cows. All of these data were lost through the burning of the barns and until some months later it was not practicable to continue these observations. It then seemed necessary and dispose of all of the least promising cows on account of the lack of stable facilities. A comparison of the relative profit after such a process of selection would be of little value and has not been attempted.

PROGRESS OF THE EXPERIMENT.

Test of June, 1902.—At this test we had thirteen sound animals, twelve from the last test and a calf from the tuberculous Millie D.

The fourteen diseased animals all reacted, including Kittie who had failed to do so at the test in 1901.

[21] The fact that all of the 25 calves fed with this milk remained free from tuberculosis is good evidence that it was really harmless.

Jane was killed just prior to the test as she was failing fast. The disease had vigorously attacked her liver which probably accounted for her breaking down in about a year after she had contracted tuberculosis.

Test of December, 1902.—In the sound herd, Belle of Spring Brook and Pet had been sold for beef. The eleven animals remaining from the previous test failed to react as did the calf of the tuberculous Aurora, giving us a total of 12 sound animals.

In the diseased herd five animals had been sold for beef and Cassy, who was breaking under the disease, was killed. The autopsy showed fairly generalized tuberculosis. Of the eight remaining cows, Cow No. 9 was not tested because she was about due to calve. The other seven were tested and all reacted except Millie D.

Test of April, 1903.—The twelve healthy animals and the three calves, all from healthy cows, failed to react making a total of 15 sound animals. The tuberculous herd was not tested. Cow No. 9 died with milk fever just after the date of the previous test, leaving but seven diseased animals.

Test of December, 1903.—The sound herd, consisting of the fifteen head at the last test, now numbered twenty, three of the five calves coming from the diseased herd. All passed the test.

In the diseased herd Aurora was not tested because she was about due to calve and of the remaining six only Chloe and Nettie gave a reaction. No satisfactory reason can be given for the failure of the other four to react.

Test of May, 1904.—The sound herd contained twenty-four animals at the date of testing, two of the four calves dropped since the last test coming from the diseased herd. A single animal, Daisy of Loch, gave a typical reaction with the tuberculin, leaving us 23 sound animals. Almost immediately following the test this cow became so lame as to be practically helpless. Treatment failed to relieve the trouble and she was killed. An autopsy showed the presence of a few tubercular lesions in the mediastinal glands. This was evidently a case of recent infection and as we obtained a reaction at the same test from a cow which had been added to the herd by purchase an explanation of the avenue of infection seems simple. This was the first case of infection in our sound herd after the separation in 1901.

The lameness was apparently not connected with tuberculosis but was probably due to accident. At least no evidence of tubercular lesions could be found in the affected joint.

With the exception of Millie D. the seven diseased cows all gave a reaction with the tuberculin. The reaction was a surprise in the case of Aurora who had been failing very rapidly and was now plainly in the last stages of the disease. It is often stated that animals in such a condition fail to react. She was killed and examined shortly after the test and was as full of diseased tissue as a cow could well be conceived of being. Her lungs were so solid that they did not collapse after death and both body cavities were so covered with tubercles as fairly to obscure the membrane upon which they rested.

Test of November, 1904.—All of the members of the sound herd failed to react. This herd now contained the twenty-three animals which were sound at the last test and two calves, both coming from diseased cows, making a total of 25.

Millie D. and Lady of Loch of the six diseased animals failed to react.

Test of May, 1905.—The sound herd now contained twenty-nine animals, of the increase 3 being due to calves from the sound herd and 1 from the diseased. All of this herd passed the test except Aurora's Fancy, leaving 28 sound animals. This was the second and the latest case of a member of our sound herd becoming diseased. This animal was the last calf dropped by Aurora at a time when the dam was in the advanced stages of the disease. The calf was always of doubtful vigor and its destruction on this account had been discussed. However, on account of the desirable breeding involved it was thought best to hold her until she had shown her ability as a milker. She was evidently not diseased from birth as she had failed to react as a yearling. Two avenues of infection may be suggested but neither of them seems satisfactory. The bull pen is in the same stable in which the young cattle are kept and our bull had given a typical reaction the year previous. Also the man who had charge of the tuberculous herd assisted in caring for the young cattle. The main difficulty with both explanations is the fact that the calf was sound at the previous test and had been placed in pasture immediately after and had remained there until

a few days preceding the test at which she had reacted. Again if the stable conditions were responsible for her infection it was strange that no similar cases have developed before or since.

With the exceptions of Kate and Millie D. all of the 6 cows in the diseased herd responded to the test. As this was the last test given to these animals, with the exception of Millie D., the record of this test is given in Table I.

TABLE I.—TEST OF DISEASED HERD, MAY, 1905.

NAME.	BREED.	Age.	Weight.	BEFORE USE OF TUBERCULIN.				Tuberculin injected 10 P. M.	AFTER USE OF TUBERCULIN.				
				A. M. 10:30.	P. M. 2:30.	P. M. 4:00.	P. M. 8:15.		A. M. 7:00.	A. M. 9:45.	A. M. 11:00.	P. M. 12:15.	P. M. 3:15.
		Yrs.	*Lbs.*	°*F.*	°*F.*	°*F.*	°*F.*	*C. c.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
Chloe	Holstein-Jersey Grade	6	1,100	101.3	102.2	101.6	101.4	2.2	103.4	105.2	104.3	102.5	101.8
Lady	Jersey	11	960	101.8	101.4	102.0	100.7	1.9	102.3	104.0	104.7	104.1	102.7
Kate	Grade Jersey	6	900	101.4	101.6	101.3	100.7	1.8	101.6	101.3	101.3	101.8	101.8
Lily	Grade Jersey	6	800	100.6	100.9	101.6	100.6	1.6	102.0	103.1	101.8	102.0	102.2
Nettie	Jersey	6	800	100.7	101.3	101.3	101.4	1.6	102.3	104.1	103.1	104.3	105.6
Millie D.	Jersey	13	950	101.2	101.1	100.9	101.2	1.9	101.6	101.8	101.6	101.2	101.9

Test of November, 1905.—The sound herd now contained the twenty-eight animals which did not react in May and two calves, one descended from each herd. None of these animals gave any reaction to the tuberculin.

Millie D. was the only member of the diseased animals which was tested at this time. She again failed to react.

This test practically closes this experiment as we had now thirty sound animals which was the total number in our herd at the time we undertook to stop the further spread of the disease and replace the diseased animals by healthy calves.

SUMMARY OF CONDITION OF STATION HERD.

Table II shows the progress of the work during the four years, giving the standing of the herds at each test as well as the changes occurring during the preceding six months. From the table it will be seen that it took four years to replace the seventeen animals which were diseased at the beginning, the two which later contracted the disease, the four which were burned with the barn, and the two which were sold, making a total of twenty-five. Of this number of calves eleven have descended from the thirteen sound animals and fourteen from the seventeen diseased animals. The contribution from the diseased herd was affected by the removal of nine of the cows during the first year of the experiment without their producing offspring and by two of the remainder producing only bull calves.

This work was carried out in the face of as many natural difficulties as can ordinarily be expected in an average dairy. It is accordingly believed that with good care the rebuilding of a similar herd can be regularly accomplished in from three to five years.

TABLE II.—SUMMARY OF CONDITION OF STATION HERD.

DATE OF TEST.		ANIMALS.			SOUND HERD.				DISEASED HERD.			
Year.	Month.	Healthy.	Diseased.	Total.	Heifer calves dropped.	Died.	Sold.	Became infected.	Heifer calves dropped.	Died.	Sold.	Killed.
1901...........	Oct..........	13	17	30	....	....	....	....	....	....	....	....
1902...........	June.........	13	14	27	....	4	....	....	4	2	....	1
1902...........	December....	12	8	20	....	....	2	....	1	....	5	1
1903...........	April.........	15	7	22	3	....	....	....	....	1	....	....
1903...........	December....	20	7	27	2	....	....	....	3	....	....	....
1904...........	May..........	23	7	30	2	....	....	1	2	....	....	1
1904...........	November....	25	6	31	....	....	....	....	2	....	....	1
1905...........	May..........	28	6	34	3	....	....	1	1	....	....	1
1905...........	November....	30	6*	36	1	....	....	....	1	....	....	0*

* The six diseased animals were killed after the November test. For their autopsy record see page 54.

THE SALE OF TUBERCULOUS COWS FOR BEEF.

The most exacting rules which are employed in this country in judging of the quality of meat for human food are those of the Bureau of Animal Industry.[22] Similar regulations are in force in many of the more highly civilized countries.[23] These rules are applied in all of the slaughter houses which are engaged in inter-state or export trade and they specifically provide that carcasses of cattle affected with tuberculosis in which the lesions do not exceed a stated limit shall be stamped the same as those from absolutely sound animals. As a result of the inspection under

[22] The regulations applying to tuberculosis cattle are given on page 33.

[23] The Royal Commission of England reports that "as a result of the inspection in 29 towns in Saxony during the year 1895 tuberculosis was found to exist in 22,758 carcasses — being 27.48 per ct. of the whole number slaughtered. Of the total number, 22,758 carcasses, showing tuberculous lesions, 21,062 or 92½ per ct. were passed as fit for food; 1,256 or about 5½ per ct. were disposed of in the Freibank as inferior meat, at a fixed cheap rate; and the remainder, 440 carcasses or 2 per ct. of the whole number pronounced tuberculous in a greater or less degree were condemned as unfit for food and destroyed. (From Report of N. Y. Assembly Committee, 1901.)

these rules, a considerable amount of beef[24] from tuberculous animals is annually included in that class which is justly considered the best beef on the American and European markets.

The animals disposed of by us were sold with the understanding that they should be sent to slaughter-houses where the carcasses would receive an official inspection.

If one studies the nature of tuberculosis, it is evident, as experiments and practice have shown, that localized lesions enclose the tubercle bacteria and that the danger from consuming the flesh of such animals is very slight. If the disease is generalized, i. e., the lesions are distributed in the organs of both the large body cavities or, according to Ostertag, if there is an old tubercular lesion and many small miliary tubercles in organs in the same body cavity, the carcass should be condemned.

Experience has shown that when reacting animals of a herd are killed, after the tuberculin test, a very large percentage of them are so slightly diseased that the lesions would have escaped notice had the animal been killed in the ordinary way for beef, or, if the changes are in evidence they would not, because of their localization, condemn the carcass. In view of the practice of various national meat inspections which have proven to be safe, it seems perfectly proper and just that animals that have reacted to tuberculin but which, from the flesh point of view, are in a fit condition for beef should be retained for food providing they pass inspection under the rules of the Federal Meat Inspection Service.

It is most unfortunate that the butchers of our small towns and cities, and often those slaughtering for home consumption in our larger cities, are permitted to sell meat from animals that are not so inspected at the time of slaughter. In the absence of such a general system, the published rules of the Federal Meat Inspection Service (see page 33) make it possible for a competent veterinarian to decide for the owner whether or not a carcass can

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[24] According to the report of the Bureau of Animal Industry its representatives, during the fiscal year 1903–'04, made post-mortem inspection of 6,383,080 cattle and 24,170,230 hogs. Of these 10,173 carcasses and 703 parts of carcasses of cattle and 34,656 carcasses and 181,820 parts of carcasses of hogs were condemned for tuberculosis.

be used with safety for food. It is hoped that in the near future the laws of this State will provide for the inspection of such animals, thereby giving the small owner an equal chance with the large packing houses for the equitable disposition of slightly infected animals.

The situation would be highly satisfactory if as consumers we could avoid eating the meat or drinking the milk of tuberculous animals, but under existing conditions we can hardly expect to do this. We shall approach perfect conditions in this respect only as we reduce the number of infected animals. There can be no hesitancy, however, in the acceptance of the statement that the inspected carcasses are much to be preferred to great quantities of home-killed beef that is sold without inspection of any kind and where the only protection the consumer has against the consumption of the meat of animals suffering from generalized tuberculosis is the opinion and conscience of a man unskilled in the nature of this disease. If the meat and milk of animals suffering from generalized tuberculosis can be excluded, a long step in advance of present conditions will have been taken.

AUTOPSY ON TUBERCULOUS COWS AT CLOSE OF EXPERIMENT.

At the close of the experiment we still had six of the diseased cows. Of these Chloe was in good condition for beef, while Millie D., who was now fourteen years old, was in poor condition. The others were in average flesh for dairy cows.

As three of these cows had been diseased for five years, or since they were calves, and the other three had been tuberculous for at least four years it seemed best to hold an autopsy on these animals in order to note the progress which the disease had made during this time.

In order to conserve the beef value which was in the cows an arrangement was made with a local butcher to buy such of the carcasses as should pass a proper inspection and were otherwise in condition for beef. The Bureau of Animal Industry kindly consented to send an inspector from Buffalo to pass upon the quality of the carcasses under the same rules in use at the slaughter houses in Buffalo and elsewhere.

The local health officer, when consulted, raised objection, on the basis of local regulations, to the sale of such Government Inspected meat which if passed would have been of the same quality as that which is being shipped to this city in car load lots and would have been immeasurably better from the standpoint of public health than much of the locally killed meat which is subjected to no inspection whatever.

Desiring to avoid any conflict with the local authorities the idea of selling the meat was abandoned, but in order to determine what value still remained in the animals the carcasses were carefully inspected. For this work we availed ourselves of the services of Dr. W. B. Mack, Assistant in the Department of Comparative Pathology and Bacteriology at the N. Y. State Veterinary College. While no longer officially connected with the Bureau of Animal Industry, Dr. Mack had just returned from Kansas City where for some months he had served as a Federal Inspector in one of the large slaughter houses. The results of the examination made by Dr. Mack of the carcasses of five of the tuberculous cows are, in reference to that disease, as follows:

POST MORTEM NOTES BY W. B. MACK, D.V.M.

GENEVA, N. Y., *Nov.* 17 and 18, 1905.

The following tubercular lesions were found:

Nettie.— Mediastinal lymphatic glands enlarged and caseated with a few slight calcareous foci in one of them. Right lung, principal lobe, contained a caseous area about 1.5 cm in diameter. In the liver substance were seven or eight tubercles from 0.5 to 1.5 cm in diameter.

Lily.— Mediastinal lymphatic glands enlarged and caseous. Extensive caseous lesions in both lungs. A large number of tubercles from 0.3 to 1 cm in diameter attached to the left costal pleura and that covering the mediastinum. Liver contained four tubercular areas from 1 to 2 cm in diameter.

Chloe.— One mediastinal lymphatic gland showed slight tubercular foci. Both prescapular lymphatic glands contained slight foci of the disease, apparently quite old.

Lady.— Mediastinal lymphatic glands enlarged and caseous with extensive caseous lesions in both lungs.

Kate.— Mediastinal lymphatic glands somewhat enlarged and contained slight tubercular foci in a calcareous condition. Left prescapular gland has two foci of the disease about 0.4 cm in diameter.

"In my opinion the cows Chloe and Kate would pass the Federal meat inspection. The lesions in the others were either too extensive, too largely distributed or in such condition as to warrant their condemnation for food."

In considering the slight progress which had been made by the disease in the case of some of these cows it should be remembered that they were what had been left by a process of selection from the entire herd of nineteen animals.

Millie D. was in such poor condition as to have little beef value. She was killed and carefully examined December 12. Her poor physical condition was evidently due to causes incident to old age as a very complete examination showed only small tubercles (about the size of a small pea), evidently well encapsulated, in three of the tracheal and mediastinal lymphatic glands. It should be remembered that this cow had not reacted for three years so that the age of the lesions can be very closely determined. Although these hard and sharply circumscribed lesions gave every appearance of dead tissue, a Guinea pig was inoculated subcutaneously with three of these little tubercles. It died in six weeks with generalized tuberculosis. This observation is important in that it shows how long these bacteria may remain alive in the encapsulated tubercles.

A STUDY OF THE METABOLISM AND PHYSIOLOGICAL EFFECTS OF CERTAIN PHOSPHORUS COMPOUNDS WITH MILCH COWS.*

W. H. JORDAN, E. B. HART AND A. J. PATTEN.

INTRODUCTION.

The metabolism and functions of the ash ingredients of cattle foods have received relatively little attention from scientific investigators up to the present time. This is true even of so important an element as phosphorus. So far, investigators have given their attention chiefly to studies of the metabolism and functions of the compounds included in the three classes, proteids, carbohydrates and fats. There is every reason for believing, however, that some of the elements which appear in plant ash sustain just as important practical relations to animal production of various kinds as do nitrogen and carbon in their various combinations.

The purpose of the investigations herein reported has been to study some of the nutritive relations and functions of the phosphorus compounds of cattle foods. The results reached in the preliminary stages of this work have already been reported in bulletins Nos. 238 and 250 in which certain conclusions as to the status of phosphorus in feeding stuffs are set forth.

PARTIAL REVIEW OF PREVIOUS INVESTIGATIONS.

In studies of phosphorus metabolism numerous experiments with small animals, as dogs, calves, lambs and pigs, have been carried on both in this country[1] and abroad[2], either with the purpose of determining the relative therapeutic values of different calcium phosphates in the pathological condition known as rickets, or their values

* A reprint of Technical Bulletin No. 1.
[1] Henry. Wis. Agrl. Expt. Sta. Ann. Rpt., 6: 15. 1889.
[2] N. Schenke. *Landw. Vers. Stat.*, 58: 19. 1903.

in aiding the development of body tissues in the young animal. The evidence is quite conclusive that certain phosphates are useful in the former case but the data covering the latter point are conflicting and it is still an open question whether calcium phosphates possess nutritive value when added to a ration of normal food materials.

Kohler[3] working with lambs found that calcium and phosphoric acid were most thoroughly assimilated in the form of precipitated calcium phosphate, which is a mixture of tri- and di-calcium phosphates. Atwater[4] has shown that the ash constituents of beef are largely absorbed from the digestive tract of man. Hoppe-Seyler[5] finds the same to be true of calcium phosphate and the several experiments of Gohren[6], Lehmann[7] and Wildt[8] give similar results with small animals.

The evidence as to the benefits derived from the use of inorganic phosphates when fed to sound animals is contradictory. Cohn[9] reports observations on the addition of calcium phosphate to the food of calves and pigs where no apparent influence was exerted, while a marked benefit was observed in experiments with two to three-year-old horses. Hofmeister[9] failed to receive beneficial returns from the use of precipitated calcium phosphate with three-months' old lambs. Heiden[10] observed an increased weight and a general beneficial influence from the addition of 25 grams of calcium phosphate to the daily food of weak pigs, but when stronger animals were used no influence was evident.

Hess and Schaffer[11] report that when 50 grams of calcium phosphate was added to the daily food of four cows the milk contained an increased proportion of that compound. The experiment station at Möckern[12] reports most beneficial results from the use of 30-50 grams of calcium phosphate in the daily rations of steers which had shown marked brittleness of their bones, caused by administering a ration poor in phosphorus. H. Joulie[13] reports

[3] *Ztschr. Untersuch. Nahr, u. Genussmtl.*, 8:683. 1904.
[4] *Ztschr. Biol.*, 24: 16. 1888.
[5] *Med. Chem. Untersuch.*, Heft 2.
[6] *Landw. Vers. Stat.*, 3: 161. 1861.
[7] *Jahresber. Agr. Chem.*, 16, Bd. 2: 183, 1876.
[8] *Jour. Landw.*, 22: 1. 1874.
[9] *Landw. Vers. Stat.*, 1873, p. 123.
[10] *Jahrsber. Agr. Chem.*, 16, Bd. 2: 62. 1876.
[11] *Landw. Jahrb. Schweiz*, 5: 76. 1891.
[12] *Landw. Vers. Stat.*, 57: 239, 1902.
[13] *Rev. Agr. Reunion*, 10: 1904.

experiments on the use of phosphoric acid for herbivora which led to the conclusion that such an addition was beneficial. H. D'-Auchald[14] found an increased weight of the skeleton of chickens which were fed a ration containing 4 grams of added bone when compared with those not receiving this addition, and Wheeler[15] has observed that the addition of bone ash improves most grain rations as food for young chicks.

Kohler[16] has lately compared the assimilability of different forms of calcium phosphate by lambs and has given to di-calcium phosphate a value four times greater than that of bone ash. H. Labbe[17] in his own work mentions the faulty assimilation of inorganic phosphorus compounds and obtained much more favorable results with such organic forms as nucleins and lecithins. Desgrez and Zaky[18] have also experimented with the lecithins and nucleins on guinea pigs, and marked gains in weight were noted when these substances were fed. Gilbert and Fournier[19] worked with young dogs with similar results. Springer[20] lays great stress on the nutritive and stimulating value of the lecithins found in cereals. It is probable that the conclusions drawn by Springer cannot all be attributed to lecithins as other phosphorus compounds were present in the mateiials he used in his experiments.

Another phase of the problem that has received attention is whether or not mineral phosphates can be utilized in the formation of such organic phosphorus structures as the nucleins. These latter bodies and the more complex nucleo-proteids are widely distributed in blood and tissues and the source of their phosphorus is a question of importance. Rohman[21] and his pupils have concluded that the animal organism has not the power to synthesize organic phosphorus combinations from phosphorus-free proteids and mineral phosphates, while Keller[22] and Ehrström[23] have deduced quite

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[14] *Jour. Agr. Prat.*, n. ser. 7, 1904.
[15] N. Y. Agr. Expt. Sta., Bul. 242.
[16] *Ztschr. Untersuch. Nahr. u. Genussmtl.*, 8: 683, 1904.
[17] *British Med. Jour.*, No. 2267, 1904.
[18] *Compt. Rend. Soc. Biol.*, (Paris), 57. 1904.
[19] Idem, 53: 145. 1900.
[20] L'Energie de Croissance.
[21] *Berliner Klinische Wochenschrift*, 1898.
[22] *Archiv. für Kinderheilkunde*, 1900.
[23] *Skandinavische Arch. für Physiologie*, Bd. 14.

contrary conclusions from their own observations and have given to the inorganic phosphates a rôle in phosphorus metabolism.

Buchmann[24] in experiments with convalescent patients in which egg-yolk with and without added lecithin and edestin formed a part of the diet, concluded that lecithin must be regarded as very important in inducing gains of tissues containing phosphorus. Since lecithin was so superior to edestin when the latter was combined with inorganic phosphates in the experiments reported, it seemed to the authors that inorganic phosphates was all excreted.

Buchmann, Ehrström[25] and Siven[26] have come to the conclusion that a definite relationship between N and P_2 O_5 excretion does not exist, as had been claimed, a relationship according to Hammarsten of 8.1 : 1.0, but that a nitrogen loss accompanied by a phosphorus storage can occur. Meyer[27] has confirmed the work of Ehrström and Chronheim and Müller[28] in that increased phosphorus in the food increases the phosphorus retained in the body and that the body can for a long period either gain or lose large quantities of phosphorus.

Herter[29] has made the interesting observation that when he fed young animals separated milk, practically free from fat, the absorption of phosphoric acid by them was for some reason or other much interfered with.

No attempt has been made here to give a complete bibliography of the subject of phosphorus metabolism but only references enough to show that in several phases the work is still inconclusive and contradictory and demands further investigation.

THE PROBLEMS STUDIED.

Our own problem, as first conceived, was the narrow one of the food compounds used by the animal for the formation of the phosphorus-bearing proteids such as are found in flesh, milk and eggs. It was thought, if nucleo-proteid synthesis does not occur in the animal body, that in the case of cows and hens where

[24] *Ztschr. für diat. und phys. Therapie,* 8.
[25] Loc. Cit.
[26] Cit. by Ehrström.
[27] *Ztschr. für Physiol. Chemie,* 43: 1. 1904.
[28] *Ztschr. für diat. and phys. Therapie,* 6: 1902.
[29] *Jour. Experimental Med.,* 3: 293. 1898.

phosphorus-bearing proteids are formed in great abundance in the milk and eggs, the kind and quantity of phosphorus compounds in the ration might have an important influence upon production. As it was believed that cattle and poultry foods probably contained both inorganic and organic phosphorus bodies in greatly varying relative and absolute quantities, it was supposed that rations might be selected which would show markedly different effects upon the secretion of phosphorus-bearing proteids and therefore upon production with cows and hens, milk and eggs being rich in these bodies.

Our views of the conditions attending our proposed investigation were much modified by an examination into the nature of the phosphorus compounds of the various grains and their by-products. In Bulletin No. 238 of this Station[30] it was first shown, and later confirmed by Schulze and Castoro,[31] that in normally grown, non-etiolated plants the phosphorus exists in the seeds wholly in organic combinations, while in the straw a small proportion occurs in inorganic forms. It was also shown in a later bulletin[32] that wheat bran, the outer layer of the wheat kernel and rich in phosphorus, contains practically all of this element in an organic combination of an entirely different nature from either the nucleins or lecithins.

This bran body is an organic acid radical coupled with calcium, magnesium and potassium and is probably identical with the compound Posternak[33] isolated from other plant tissues and to which he gave the name of phytin.[34] Phytin is widely distributed in nature and has been found in the seeds of red fir, pumpkin, peas, beans, white and yellow lupines, potatoes and wheat.

It can be completely or nearly removed from wheat bran by mere washing with water, but more easily by allowing the bran to undergo a slight acid fermentation followed by leaching with water. It is this fact that allowed us to prepare a ration very low in its phosphorus content.

[30] N. Y. Agr. Expt. Stat. Bul. 238, 1903, and *Amer. Chem. Jour.*, 30: 470. 1903.
[31] *Ztschr. Physiol. Chem.*, 41: 477. 1904.
[32] N. Y. Agr. Expt. Stat. Bul. 250, 1904, and *Amer. Chem. Jour.*, 31: 564. 1904.
[33] *Rev. Gen. Bot.*, 124: 5. 1900.
[34] *Schweiz. Wochenschr. Phar.*, 42: 1904.

GENERAL PLAN OF THE INVESTIGATION.

Our studies for the past two years have been conducted with milch cows and in connection with observations that are to follow have been arranged in accordance with the following general plan.

1. Feeding to the same animal during short or long periods of time rations differing greatly in the amount of phosphorus which they supply, this variation in phosphorus content to be brought about, as far as possible, by selection of the components of the ration, but the differences in quantity of ingested phosphorus to be intensified both by special treatment of the ration and by adding to it particular phosphorus-bearing bodies, the effect of which it is desired to study.

2. Modification of the phosphorus content of the ration by variations as far as possible in the amount present of a particular phosphorus-bearing body.

3. The changes from a high, to a low, phosphorus ration to be both abrupt and gradual.

4. The maintenance of the rations on the same nutritive plane, excepting in the variations of the phosphorus content.

5. The feeding of weighed and carefully sampled rations and the collection and weighing of the excreta and product, to be accompanied by such chemical determinations as are essential to the solution of the problem in hand.

It was expected that this plan of work would furnish data on the following points.

1. The amounts and kinds of phosphorus-bearing bodies in certain cattle foods. (Already published.)

2. The transformations and distribution of phosphorus-bearing bodies brought about by the metabolic changes in the animal.

3. The influence of the supply of phosphorus compounds both in kind and in quantity, upon the physiological status of the animal and upon the composition and yield of product, whether milk or otherwise.

EXPERIMENT I.

This was a comparison of the effect of rations differing greatly in their phosphorus content, especially in phytin phosphorus.

THE EXPERIMENTAL ANIMAL.

The animal (Cow 1) selected for use in our first experiment was a vigorous grade Holstein. When the experiment began she was in fair flesh and about three months advanced in the period of lactation. She possessed a vigorous appetite, a characteristic which we regarded as essential to the entire consumption of the ration containing the washed bran because of its probable lack of palatableness. It is a matter for congratulation that the regular consumption of the rations was accomplished with a very satisfactory degree of success.

THE MANAGEMENT OF THE EXPERIMENT.

The animal under observation stood by herself in a warmed room especially arranged for experimental work. She was fed from a metal-lined box which allowed the attendant to recover all uneaten food. The daily ration was given in three equal portions, morning, noon and night. Water was offered at stated times and the animal was weighed at the same hour each day. Two men were employed for the collection of the excreta, one during the night and the other during the day. The excreta were caught in tin vessels, the one used for the urine being so constructed as to prevent loss by spattering. There was a loss of urine in but a single instance and that was small. The weights of urine and feces recorded represent that which was voided during twenty-four hours, from 6 o'clock a. m. The animal was milked four times a day at as nearly uniform time as practicable, viz., 7 a. m., noon, 5 p. m., and midnight.

THE RATIONS.

The first matter requiring attention in the experiment was the selection or preparation of foods containing small amounts of phosphorus. It was found that rice, wheat gluten and oat straw were as low in phosphorus as any feeds that could be selected and these, combined with the washed wheat bran, constituted the ration low in phosphorus.

The extraction of phytin from the wheat bran was easily accom-

plished. The bran was allowed to soak over night in warm water, a slight acid fermentation being induced. When the water showed a slight acidity to litmus, the bran was placed in sacks and thoroughly leached with more water. After being air-dried it was ready for use.

The high phosphorus ration was made up from oat straw, hominy, whole wheat bran and wheat gluten. Through the use of the wheat gluten which contained from 70 to 75 per cent. of protein, it was easy to regulate the protein supply so as to make it fairly uniform in the two rations.

METHOD OF SAMPLING AND ANALYSIS.

The rations were weighed out at several different times during the course of the experiment and each time this was done samples were taken of the various feeds. The similarity in composition of these several portions indicates that the mixing and sampling were thoroughly accomplished. The milk, urine and feces were taken directly to the laboratory and immediately weighed and sampled, excepting that the noon and night's milk was kept in an icebox until morning when the product for an entire day was thoroughly mixed together and sampled. Reserve samples of milk and urine were always kept, fermentative changes in these being prevented by the use of formaldehyde and toluol. The feces were thoroughly mixed by prolonged stirring and five pound samples of the fresh material were taken for drying and for nitrogen determinations. These samples were dried over steam coils at a temperature not exceeding 60° C.

In general the analytical methods of the A. O. A. C. were followed. During some of the time the fat in the milk was estimated both by the Babcock and ether extraction methods. Neumann's method was used in all the total phosphorus determinations. For the separation of inorganic from organic phosphorus the method described in Bulletin No. 238 of this Station was employed. This method also gave an opportunity to estimate what we have called "fixed" phosphorus and which probably quite closely represents the phosphorus of the true nucleo-proteids and nucleins. In the urine only total phosphorus was determined, as attempts to separate inorganic from organic forms, even if the latter existed in appreciable quantities, were futile.

THE CHARACTER AND SEQUENCE OF THE RATIONS IN THE PHYTIN EXPERIMENT.

This experiment, which was begun in February, 1904, was based chiefly on variations in the phytin content of the rations and was finally executed in general accordance with the following scheme:

Ration 1.—A low phosphorus ration was fed from noon March 8 to the morning of March 17. The animal had been slowly brought to this ration by preliminary feeding for 9 days previous to March 8.

Transition period.—A gradual change from a low phosphorus ration to one high in phosphorus, occupying from noon March 17 to the morning of April 5. During this period the washed bran was decreased one-half pound daily, the same amount of the whole bran being substituted. The rice was decreased by about one-third of a pound per day and the hominy feed increased one-fourth of a pound. The wheat gluten was decreased 12 grams or about one-fortieth of a pound daily.

Ration 2.—The high phosphorus ration was fed from noon April 5 to the morning of April 19. This ration differed from Ration 1 in that its content of phytin phosphorus was approximately twenty times as large.

Ration 1.—Sudden change from a high phosphorus ration to one low in phosphorus, the latter being fed from noon April 19 to the morning of May 2. This ration was eaten satisfactorily until the morning of April 24 when it was refused. The animal became seriously constipated and as impaction was feared, one-half pound of Epsom salts was administered with negative results. On April 25, one and one-fourth pounds of Epsom salts was given and the ration withheld at noon. This produced the desired result and the animal began to eat again on the 26th, only part of the ration being given. The amount fed was increased until on the 28th of April the cow was receiving her full ration (Ration 1) and appeared perfectly normal.

Ration 2.—Sudden change from the low phosphorus ration to the one high in phosphorus. Ration 2 fed from noon May 2 to the morning of May 15.

Transition period.—From noon May 15 to noon May 20. During this period the unwashed bran was decreased 2 pounds daily

and the washed bran substituted by the same amount. The hominy feed was decreased 1 pound daily and the rice increased 1½ pounds daily. The wheat gluten was increased about 1-5 pound daily. Marked dryness of the feces accompanied this transition but the animal continued to consume all the ration.

Ration 1.—The low phosphorus ration was fed from noon May 20 to the morning of June 17.

Ration 2.—Sudden change from a low phosphorus, to a high phosphorus, ration, the latter being fed from noon June 17 to the morning of June 24.

This experiment covered 108 days. The collection and analysis of the urine and feces covered 71 days, this being done continuously during 54 days. A complete analysis of the milk was made daily.

NUMERICAL RESULTS OF THE EXPERIMENT.

Extensive data were necessarily recorded in an experiment involving such numerous weighings and analyses during a period of over three months. The figures herewith presented are confined to those which are essential to a critical analysis of our conclusions.

The tables are made up either of daily records or of averages for certain periods and cover those times when it was believed that the animal had adjusted herself to the ration being fed. In some cases the effects of the transition periods are shown. The tables that follow are arranged under the following heads:

Table 1.—The rations fed.

Table 2.—The composition of the feeding stuffs used.

Table 3.—Quantities and percentages of digestible nitrogen and dry matter fed.

Table 4.—Percentage composition of the milk with both high and low phosphorus ingestion, including a transition period.

Table 5.—Percentages of various forms of phosphorus in milk.

Table 6.—Total phosphorus balances.

Table 7.—Distribution and balances of nucleo-proteid phosphorus.

Table 8.—Distribution and balances of soluble organic phosphorus compounds.

Table 9.—Distribution and balances of inorganic phosphorus compounds.
Table 10.—Relation between nitrogen and phosphorus excretion.
Table 11.—Effects of the ingestion of phosphorus compounds upon the composition of the milk, shown by periods.
Table 12.—Effects of the ingestion of phosphorus compounds upon the yield of milk and milk solids and upon the excretion of urine.

TABLE I.—THE RATIONS FED.

INGREDIENTS.	Ration. No. 1.	INGREDIENTS.	Ration. No. 2.
Oat straw	10 lbs.	Oat straw	10 lbs.
Washed bran	10 "	Whole bran	10 "
Rice	6 "	Hominy	5 "
Wheat gluten	1½ "	Wheat gluten	1 "
Total	27½ lbs.	Total	26 lbs.

TABLE II.—THE COMPOSITION OF THE FEEDING STUFFS USED.

Lab. No.	FEEDS.	Water.	Protein.	Fat.	PHOSPHORUS.		
					Total.	Soluble.	Inorganic.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	Oat straw	18.29	2.34	1.87	.151	.082	.058
7	Wheat gluten	7.71	72.12	1.39	.201	.056	.00
3	Rice	14.05	8.37	.33	.076	.011	.00
8	Washed bran	7.23	11.19	4.07	.099	.013	.00
2	Whole bran	12.13	14.50	4.42	1.32	.98	.00
38	Hominy	14.41	9.25	5.81	.457	.27	.00

TABLE III.—QUANTITIES AND PERCENTAGES OF DIGESTIBLE NITROGEN AND DRY MATTER FED.

DATE.	Total phosphorus. fed.	DRY MATTER DAILY.			NITROGEN DAILY.		
		Fed.	In feces.	Digested.	Fed.	In feces.	Digested.
	Grms.	*Grms.*	*Grms.*	*Per ct.*	*Grms.*	*Grms.*	*Per ct.*
March 10-16	12.8	8908	2872	67.7	178	52	71.6
April 12-18	78.7	10039	3782	62.3	210	59	71.7
April 28-May 1	16.0	10863	4471	58.8	215	79	63.3
May 9-15	83.3	10214	3993	61.0	215	64	70.1
May 22-26	21.4	11335	4018	64.5	216	70	67.4
June 10-16	15.1	11354	4537	60.0	224	82	63.3

TABLE IV.—PERCENTAGE COMPOSITION OF THE MILK WITH BOTH HIGH AND LOW PHOSPHORUS INGESTION, INCLUDING A TRANSITION PERIOD.

DATE.	Phosphorus fed daily.	IN MILK.					DATE.	Phosphorus fed daily.	IN MILK.				
		Proteids.	Casein.	Fat.	Sugar.	Solids.			Proteids.	Casein.	Fat.	Sugar.	Solids.
RATION 2.	Grms.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	TRANSITION.	Grms.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
May 9	83	2.65	2.25	3.25	5.64	11.54	May 22	21	2.66	2.16	2.20	5.91	10.67
10	83	2.64	2.13	3.50	5.68	11.82	23	21	2.67	2.23	2.15	6.04	10.91
11	83	2.68	2.21	3.40	5.70	11.78	24	21	2.66	2.20	2.25	6.00	10.81
12	83	2.46	2.00	3.35	5.61	11.42	25	21	2.61	2.12	2.30	5.96	10.82
13	83	2.62	2.15	3.35	5.72	11.69	26	21	2.62	2.19	2.45	5.84	10.76
14	83	2.61	2.22	3.20	5.55	11.56	27	21	2.69	2.29	2.60	5.79	10.93
15	83	2.69	2.25	3.05	5.34	11.23	RATION 1.						
TRANSITION.							28	15.6	2.70	2.26	2.60	5.69	10.99
16	69	2.68	2.18	2.85	5.83	11.56	29	15.6	2.70	2.34	2.70	5.80	11.10
17	55	2.60	2.17	2.40	6.09	11.54	30	15.6	2.63	2.36	2.80	5.85	11.18
18	36	2.59	2.20	2.25	5.91	11.35	31	15.6	2.73	2.34	2.90	5.83	11.36
19	29	2.59	2.18	2.20	6.07	11.06	June 1	15.6	2.70	2.29	2.80	5.87	11.47
20	21	2.65	2.25	2.10	5.97	10.87	2	15.6	2.55	2.16	2.70	5.93	11.28
21	21	2.62	2.18	2.20	5.91	10.73							

TABLE V.—PERCENTAGES OF VARIOUS FORMS OF PHOSPHORUS IN THE MILK.

Date.	Total phosphorus fed daily.	Phosphorus in milk.			Date.	Phosphorus fed daily.	Phosphorus in milk.		
		Total.	Soluble.	Inorganic.			Total.	Soluble.	Inorganic.
RATION 2.	*Grms.*	*Per ct.*	*Per ct.*	*Per ct.*	TRANSITION.	*Grms.*	*Per ct.*	*Per ct.*	*Per ct.*
May 9	83	.082	.071	.063	May 22	21	.094	.071	.069
10	83	.078	.068	.060	23	21	.091	.074	.072
11	83	.083	.066	.056	24	21	.092	.075	.072
12	83	.076	.065	.059	25	21	.093	.074	.074
13	83	.083	.065	.061	26	21	.093	.071	.073
14	83	.083	.070	.065	27	21	.090	.070	.070
15	83	.084	.064	.062					
					RATION 1.				
TRANSITION.					28	15.6	.090	.077	.072
16	69	.083	.067	.065	29	15.6	.091	.072	.076
17	55	.084	.066	.063	30	15.6	.089	.070	.072
18	36	.086	.068	.066	31	15.6	.092	.073	.076
19	29	.079	.070	.063	June 1	15.6	.092	.072	.060
20	21	.080	.066	.065	2	15.6	.079	.075	.065
21	21	.093	.067	.065					

TABLE VI.—TOTAL PHOSPHORUS BALANCES.

DATE.	DAILY INCOME AND OUTGO OF PHOSPHORUS.				
	Fed daily.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*
March 10-16	12.8	22.7	8.4	14.2	.10
April 12-18	78.7	70.6	55.7	11.0	3.90
April 28-May 1	16.0	23.8	13.29	10.1	.37
May 9-15	83.3	70.4	56.7	8.8	4.88
May 22-26	21.4	22.7	9.59	13.0	.11
June 18-24	15.1	20.5	9.4	11.0	.12

TABLE VII.—DISTRIBUTION AND BALANCES OF NUCLEO-PROTEID PHOSPHORUS.

DATE.	Total phosphorus fed daily.	DAILY INCOME AND OUTGO OF FIXED PHOSPHORUS.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
March 10-16	12.8	7.6	6.6	3.9	2.6	.00
April 12-18	78.7	24.4	9.5	7.6	1.9	.00
April 28-May 1	16.0	9.0	8.7	6.9	1.8	.00
May 9-15	83.3	28.6	7.5	5.8	1.7	.00
May 22-26	21.4	14.2	7.7	5.2	2.4	.00
June 18-24	15.1	7.5	7.8	5.2	2.6	.00

TABLE VIII.—DISTRIBUTION AND BALANCES OF SOLUBLE ORGANIC PHOSPHORUS COMPOUNDS.

DATE.	Total phosphorus fed daily.	DAILY INCOME AND OUTGO OF SOLUBLE ORGANIC PHOSPHORUS.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
March 10-16	12.8	2.5	2.0	1.8	.37	.00
April 12-18	78.7	51.1	4.1	3.9	.16	.00
April 28-May 1	16.0	4.3	2.0	1.4	.56	.00
May 9-15	83.3	52.1	6.2	5.3	.95	.00
May 22-26	21.4	3.7	2.2	1.7	.52	.00
June 18-24	15.1	4.1	1.6	.98	.64	.00

TABLE IX.—DISTRIBUTION AND BALANCES OF INORGANIC PHOSPHORUS COMPOUNDS.

DATE.	Total phosphorus daily.	DAILY INCOME AND OUTGO OF INORGANIC PHOSPHORUS.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
March 10-16	12.8	2.63	14.2	2.8	11.3	.10
April 12-18	78.7	2.6	56.6	44.1	8.6	3.9
April 28-May 1	16.0	2.6	13.1	4.9	7.9	.37
May 9-15	83.3	2.6	57.2	45.6	6.7	4.9
May 22-26	21.4	3.5	12.7	2.6	10.0	.11
June 18-24	15.1	3.4	11.9	3.2	8.6	.12

TABLE X.—RELATION BETWEEN NITROGEN AND PHOSPHORUS OUTGO.

DATE.	NITROGEN.		DAILY INCOME AND OUTGO OF PHOSPHORUS.					
	Fed daily.	Outgo daily.	Fed.	*Soluble fed.	Inorganic fed.	Excreted.	*Soluble excreted.	Inorganic excreted.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
March 10-16	178	190	12.8	5.18	2.6	22.7	16.2	14.2
April 12-18	209	205	78.7	53.7	2.6	70.6	60.8	56.7
April 28-May 1	215	215	16.0	6.9	2.6	23.8	15.2	13.1
May 9-15	215	208	83.3	54.7	2.6	70.4	62.9	57.1
May 22-26	216	200	21.4	7.27	3.5	22.7	14.9	12.7

* The soluble includes the inorganic.

TABLE XI.—EFFECTS OF THE INGESTION OF PHOSPHORUS COMPOUNDS UPON THE COMPOSITION OF THE MILK, SHOWN BY PERIODS.

DATE.	Total phosphorus fed.	IN THE MILK.				
		Proteids.	Casein.	Fat.	Sugar.	Solids.
	Grms.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
March 10-16	12.8	2.52	2.08	3.26	5.59	11.37
April 12-18	78.7	2.55	2.12	3.11	5.62	11.28
April 28-May 1	16.0	2.58	2.16	2.55	5.65	10.78
May 9-15	83.3	2.61	2.15	3.37	5.65	11.65
May 22-26	21.4	2.64	2.18	2.20	5.95	10.80
June 10-16	15.1	2.77	2.31	2.93	5.64	11.30
June 18-24	80.7	2.73	2.31	3.27	5.48	11.47

TABLE XII.—EFFECTS OF THE INGESTION OF PHOSPHORUS COMPOUNDS UPON THE YIELD OF MILK AND MILK SOLIDS AND UPON THE EXCRETION OF URINE.

DATE.	Total phosphorus fed.	Yield milk daily.	DAILY YIELD MILK SOLIDS.			Yield urine.
			Casein nitrogen.	Fat.	Solids.	
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
March 10-16	12.8	16335	53.1	531	1856	4974
April 12-18	78.7	12813	42.8	400	1454	10555
April 28-May 1	16.0	12027	40.8	306	1296	9560
May 9-15	83.3	11018	37.5	368	1276	12723
May 22-26	21.4	13833	47.4	305	1495	10147
June 10-16	15.1	12043	43.6	350	1359	
June 18-24	80.7	10428	37.8	341	1204	

DISCUSSION OF RESULTS OF EXPERIMENT I.

The following is a somewhat concise statement of the main results of the foregoing experiment, a fuller discussion being reserved until after a consideration of the outcome of further experiments.

1. *The comparative nutritive value of the rations.*—It is shown by the figures of Table 3 that outside of the changes brought

about by washing the bran there was nothing in the kind, quantities, or variations in the nutrients fed that could account for the different effect of the two rations. The digestible dry matter consumed varied from 13.3 pounds to 16.1 pounds daily, of which from 2.6 pounds to 2.9 pounds consisted of digestible protein. In no period was the ration so scanty as to produce abnormal results and the change in the quantity of digestible dry matter and protein eaten did not especially favor either ration.

2. *The amounts and forms of ingested phosphorus in the two rations.*—The amounts of phosphorus ingested in the several periods varied greatly, ranging from 12.8 grams to 21.4 grams daily in the low phosphorus period, the daily quantities in the three high phosphorus periods being 78.7 grams, 83.3 grams and 80.7 grams. These differences were brought about chiefly by removing the phytin from the bran, 62 per ct. to 65 per ct. of the phosphorus supply in ration No. 2, or from 51 to 52 grams daily, being carried in this compound. The daily amount of fixed phosphorus in ration 2 varied from 24.4 to 28.6 grams or from 31 per cent. to 34 per cent. of the whole. The quantity of proteid phosphorus in this ration was two or three time greater than that of ration 1, because of the fact that the unwashed bran and hominy feed contained much more phosphorus in insoluble forms than did the washed bran and rice. The amount of inorganic phosphorus fed, which was found entirely in the straw, was very small and was uniform in quantity. It is clear, therefore, that in studying the comparative effect of these two rations as far as phosphorus compounds are concerned, our attention should be fixed mainly upon phytin and what we have designated as the fixed phosphorus compounds or what doubtless approximate very closely to the nucleoproteids and nucleins. (See Tables 6 and 7.)

3. *The relation in amounts and forms of the ingested and the excreted phosphorus.*—The amount of outgoing phosphorus followed in a general way the quantity ingested, but within narrower limits. It is interesting to note that the animal excreted considerably more phosphorus than she received during the time that the washed bran ration was being fed. The fact is worthy of record that she was maintained in an apparently healthy condition on a ration which supplied 21.2 grams of phosphorus daily from May 20 to May 26,

and only 15.6 grams daily from May 26 to June 16, and at the end of the 27 days she was found to be losing an average of 26 grams per day.

On the other hand, when the supply of phosphorus was liberal (Ration 2) there was a storage of that element in the body of the cow, amounting in one period to an average of 8 grams daily, while in another the average was 13 grams.

The proportionate distribution of the outgoing phosphorus among its various compounds was quite unlike what was found in the food. Through catabolic changes all, or nearly all, the phosphorus of the phytin and of the unused digested proteids was reduced to inorganic forms which were excreted. The variations in the quantities of the outgoing phosphorus in the several periods were found, therefore, to consist almost wholly of changes in the proportions of inorganic salts of this element in the egesta. The data furnish no evidence that any synthesis of the phosphorus-bearing proteids occurred. The quantities of these latter bodies in the milk and egesta appear in no case to be materially greater than the food supply. (See Tables 6–9.)

4. *Distribution of outgoing phosphorus compounds in the milk and egesta.*—Variations in the amount of outgoing phosphorus, corresponding to the rise and fall of phosphorus compounds in the rations, took place chiefly in the feces, though to a small extent in the urine. Moreover, as previously indicated, this increase or decrease in the phosphorus bodies of the egesta was found to occur almost wholly with the inorganic salts. The percentage of these salts in the milk suffered no appreciable change. The proportions of organic phosphorus bodies remained fairly constant in the milk and egesta in spite of marked changes in the quantities of the ingested phosphorus compounds. It is especially noteworthy that the secretion of casein, the characteristic nucleo-proteid of milk, seemed to be in no way affected by the food supply of similar bodies or by variations in the phosphorus supply in other forms of combination, even when there was a phosphorus deficiency during a long period. (See Tables 6–9.)

5. *Physiological effects due to variations in the phosphorus bodies of the two rations.*—No evidence appears that the increase or decrease of the phosphorus compounds in the ration influenced either the digestibility of the total dry matter or of the nitrogen com-

pounds, neither was the storage or excretion of nitrogen apparently affected. No relation was found to exist between the nitrogen and phosphorus balances. Certain well defined and marked effects were observed, however. (See Tables 3 and 10.)

In our attempts at transition from one ration to the other we soon learned that it was not possible to change the cow suddenly from a ration rich in phytin to one low in this compound and keep the animal in normal health. Such a change caused her to become seriously constipated and recourse to a purgative was necessary. When the change from the unwashed bran to the washed bran ration was made slowly the animal gave no evidence of serious disturbance of health and appetite but the feces always became much darker in color and much dryer.

The removal of the phytin from the bran had the effect of materially diminishing the volume of urine. Marked changes in the amount and character of the milk secreted were also observed. The transition from the high-phytin, to the low-phytin, ration caused an increase in the volume of milk accompanied by very large decrease in its percentage of fat. As shown in Table 4, the maximum decrease in fat amounted to 1.4 per ct. and kept pace with the withdrawal of phytin from the ration. The total solids decreased about .8 per ct. Table 4 also shows that the maximum decrease in the percentage of fat was not permanently maintained but that even during the feeding of the low phosphorus ration there was a slow restoration of the proportion of fat, although the percentage did not rise to as high a point as was found during the feeding of the high phytin ration. (See Tables 4, 11 and 12.)

6. *Influence of the two rations upon production.*—Although the increase in milk flow tended to counteract the decreased percentage of fat, nevertheless the total fat production in a given length of time was considerably lessened by the substitution of washed bran for the unwashed. Similar results did not obtain with the total solids and casein. (See Table 12.)

7. *Oestrum period.*—It is a very suggestive fact that the oestrum appeared with this animal for the last time on June 12, a disturbance which followed a long continued feeding of the washed bran ration. Whether the cessation of this period was in any way connected with the removal of the phosphorus and its associated elements from the bran can be at present only a matter of theory.

EXPERIMENT II.

This was a comparison of rations carrying varying quantities of nucleo-phosphorus, with minor differences in their phytin content.

In the winter of 1904–1905, another experiment was carried on in continuation of the work described on the foregoing pages. As stated, our original plan involved mainly a study of the influence on milk secretion of rations rich and poor in nucleo-phosphorus. This second experiment was planned, therefore, with especial reference to this phase of our general investigation. Its general procedure was very similar to that followed in the first experiment, viz., the feeding of two rations in different periods which differed in an emphatic way in their content of a particular class of phosphorus-bearing bodies. In this instance the variation was made with those phosphorus compounds insoluble in dilute hydrochloric acid, consisting mainly of the nucleo-proteids and nuclein.

THE EXPERIMENTAL ANIMAL.

This animal (Cow 2) was a vigorous grade Holstein weighing 966 pounds, that was in good condition when placed in the experiment and was from one to two months advanced in the period of lactation. She manifested a vigorous appetite throughout the entire experiment and consumed daily all the food offered. Her health remained apparently unimpaired by the food and treatment which she received.

MANAGEMENT OF THE EXPERIMENT.

The details as to the place where the experiment was conducted, the collection of milk and excreta, the sampling and analyses of the foods and excreta and the feeding of the rations, were in all respects quite like those of the first experiment. The fat in the milk was estimated by both the Babcock and the ether-extraction methods. The results by these two methods agreed so closely that the figures obtained by the Babcock method are the ones used.

THE RATIONS.

Variations in the supply of nucleo-phosphorus in the rations were accomplished in the following manner: A basal ration was compounded consisting of rice, washed bran and oat straw. To this was added germ oil meal in order to increase the supply of nucleo-phosphorus. This meal was found to be especially rich in forms of phosphorus insoluble in dilute hydrochloric acid. An estimation of the purin bases, after cleavage with dilute hydrochloric acid, showed

this material to be rich in nucleins, assuming, of course, that these bases can only originate from nucleo structures. The ration poor in nucleo-phosphorus was compounded by withdrawing the germ oil meal and substituting for it wheat gluten and rice meal. It was expected that the amounts of digestible dry matter and protein would be quite similar in the two rations.

CHARACTER AND SEQUENCE OF THE RATIONS.

During a preliminary period ration 1 was fed for several days in order to adjust the animal to its influences before observations were taken.

Ration 1.—Maximum amount of nucleo-phosphorus. Observations with this ration were begun at noon December 20, this period continuing to the morning of January 3.

Transition period.—From noon January 3 to the morning of January 6. During this period the germ oil meal was reduced 1½ pounds daily and the rice was increased 1 pound daily. One-half pound of wheat gluten was added each day.

Ration 2.—Minimum amount of nucleo-phosphorus. This ration was fed from noon January 6 to the morning of January 19.

Ration 1.—A sudden change was made from ration 2 to ration 1 and the latter was fed from noon January 19 to the morning of February 2.

Ration 2.—A sudden change was made from ration 1 to ration 2 and the latter was fed from noon February 2 to the morning of February 16.

The period of observation in this experiment covered 58 days, during which time there was a continuous collection and analysis of the milk and excreta.

THE NUMERICAL RESULTS OF THE EXPERIMENT.

As in the discussion of the first experiment the tables are made up either of daily records or of averages for periods in which it was believed the animal had become adjusted to the ration that was being fed. A great mass of data was accumulated which is presented in a summarized form. The tables that follow are displayed under several heads.

Table 13.—The rations fed.

Table 14.—The composition of the feeding stuffs used.

Table 15.—Quantities and percentages of digestible nitrogen and dry matter fed.

Table 16.—Percentage daily composition of the milk with both high and low phosphorus ingestion, including two transition periods.

Table 17.—Percentages of various forms of phosphorus in milk.

Table 18.—Total phosphorus balances.

Table 19.—Distribution and balances of nucleo-phosphorus.

Table 20.—Distribution and balances of soluble phosphorus compounds.

Table 21.—Distribution and balances of inorganic phosphorus compounds.

Table 22.—Relation between nitrogen and phosphorus excretion.

Table 23.—Effects of the ingestion of phosphorus compounds upon the composition of the milk.

Table 24.—Effects of the ingestion of phosphorus compounds upon the yield of milk and milk solids and upon the excretion of urine.

TABLE XIII.—THE RATIONS FED.

INGREDIENTS.	Ration No. I.	INGREDIENTS.	Ration No. II.
Oat straw	10 lbs.	Oat straw	10 lbs.
Washed bran	10 "	Washed bran	10 "
Corn germ meal	6 "	Wheat gluten	2 "
Rice meal	3 "	Rice meal	7 "
Total	29 lbs.	Total	29 lbs.

TABLE XIV.—THE COMPOSITION OF THE FEEDING STUFFS USED.

FEEDS.	Water.	Protein.	Fat.	PHOSPHORUS. Total.	PHOSPHORUS. Soluble.	PHOSPHORUS. Inorganic.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Oat straw	9.76	4.25	1.87	.156	.127	.102
Washed bran	8.40	10.93	4.13	.145	.054	.00
Rice meal	13.04	7.25	.33	.074	.006	.00
Corn germ meal	8.26	22.50	8.70	.817	.271	.00
Wheat gluten	6.84	72.80	1.44	.073	.008	.00

TABLE XV.—QUANTITIES AND PERCENTAGES OF DIGESTIBLE NITROGEN AND DRY MATTER FED.

DATE.	Total phosphorus fed daily.	DRY MATTER DAILY. Fed.	DRY MATTER DAILY. In feces.	DRY MATTER DAILY. Digested.	NITROGEN DAILY. Fed.	NITROGEN DAILY. In feces.	NITROGEN DAILY. Digested.
	Grms.	*Grms.*	*Grms.*	*Per ct.*	*Grms.*	*Grms.*	*Per ct.*
Dec. 27-Jan. 2	37	12056	4917	59.2	226.1	93.2	58.7
Jan 13-Jan. 19	18	11906	4236	64.4	270.5	83.5	69.1
Jan. 27-Feb. 2	37	11967	4676	60.9	229.9	87.4	61.9
Feb. 10-Feb. 16	20	11831	4408	62.2	289	84.6	70.7

Table XVI.—Percentage Daily Composition of the Milk with both High and Low Phosphorus Ingestion, Including Two Transition Periods.

Date.	Phosphorus fed.	In milk. Proteids.	In milk. Casein.	In milk. Fat.	In milk. Sugar.	In milk. Solids.	Date.	Phosphorus fed.	In milk. Proteids.	In milk. Casein.	In milk. Fat.	In milk. Sugar.	In milk. Solids.
	Grms.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		*Grms.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Dec. 30	37	2.56	2.13	2.70	5.47	10.73	Jan. 30	37	2.70	2.23	2.80	5.68	11.18
31	37	2.55	2.06	2.85	5.52	10.92	31	37	2.65	2.25	2.75	5.81	11.21
Jan. 1	37	2.53	2.06	2.85	5.51	10.89	Feb. 1	37	2.75	2.23	2.75	5.68	11.18
2	37	2.53	2.08	2.80	5.51	10.84	2	37	2.64	2.21	2.65	5.72	11.01
3	32	2.53	2.03	2.80	5.56	10.89	3	18	2.74	2.27	2.70	5.69	11.13
4	27	2.58	2.06	3.15	5.51	11.24	4	18	2.80	2.34	2.65	5.61	11.06
5	23	2.63	2.18	2.65	5.44	10.72	5	20	2.82	2.30	2.60	5.60	11.02
6	18	2.77	2.18	2.70	5.36	10.83	6	20	2.76	2.21	2.70	5.51	10.97
7	18	2.65	2.10	2.40	5.67	10.72	7	20	2.77	2.23	2.55	5.43	10.75
8	18	2.75	2.12	2.50	5.44	10.69	8	20	2.74	2.22	2.40	5.56	10.70
9	18	2.65	2.13	2.55	5.67	10.87	9	20	2.77	2.27	2.40	5.68	10.85
10	18	2.73	2.18	2.45	5.67	10.85	10	20	2.80	2.25	2.45	5.53	10.78
11	18	2.69	2.15	2.70	5.52	10.91	11	20	2.81	2.27	2.60	5.37	10.87
12	18	2.73	2.16	2.75	5.47	10.95	12	20	2.79	2.22	2.65	5.73	11.17

TABLE XVII.—PERCENTAGES OF VARIOUS FORMS OF PHOSPHORUS IN THE MILK.

Date.	Fed daily.	Phosphorus in milk.			Date.	Fed daily.	Phosphorus in milk.		
		Total.	Soluble.	Inorganic.			Total.	Soluble.	Inorganic.
	Grms.	Per ct.	Per ct.	Per ct.		Grms.	Per ct.	Per ct.	Per ct.
Dec. 30	37	.102	.083	.072	Jan. 6	18	.109	.086	.071
31	37	.104	.084	.071	7	18	.106	.084	.074
Jan. 1	37	.103	.083	.065	8	18	.104	.085	.074
2	37	.102	.080	.071	9	18	.104	.086	.078
3	32	.100	.084	.069	10	18	.104	.083	.078
4	27	.103	.081	.067	11	18	.104	.082	.069
5	23	.104	.081	.068	12	18	.107	.087	.073

TABLE XVIII.—TOTAL PHOSPHORUS BALANCES.

DATE.	DAILY INCOME AND OUTGO OF PHOSPHORUS.				
	Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*
Dec. 27–Jan. 2	37	42	24.4	17.5	.12
Jan. 13–19	18	30.2	11.6	18.5	.09
Jan. 27–Feb. 2	37	39.8	22.1	17.6	.07
Feb. 10–16	20	29.2	10.9	18.2	.07

TABLE XIX.—DISTRIBUTION AND BALANCES OF NUCLEO-PHOSPHORUS.

DATE.	Total phosphorus fed daily.	DAILY INCOME AND OUTGO OF FIXED PHOSPHORUS.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
Dec. 27–Jan. 2	37	21.5	11.4	8.0	3.4	.00
Jan. 13–19	18	9.5	9.7	6.1	3.6	.00
Jan. 27–Feb. 2	37	21.2	11.4	7.9	3.5	.00
Feb. 10–16	20	11.4	10.5	6.8	3.7	.00

TABLE XX.—DISTRIBUTION AND BALANCES OF SOLUBLE PHOSPHORUS COMPOUNDS.

DATE.	Total phosphorus fed daily.	DAILY INCOME AND OUTGO OF SOLUBLE ORGANIC PHOSPHORUS.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
Dec. 27–Jan. 2	37	11.1	3.3	1.4	1.9	.00
Jan. 13–19	18	4.1	3.2	1.4	1.8	.00
Jan. 27–Feb. 2	37	11.2	3.2	1.5	1.7	.00
Feb. 10–16	20	4.8	2.9	.7	2.2	.00

TABLE XXI.—DISTRIBUTION AND BALANCES OF INORGANIC PHOSPHORUS COMPOUNDS.

DATE.	Total phosphorus fed daily.	DAILY INCOME AND OUTGO OF INORGANIC PHOSPHORUS.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
Dec. 27–Jan. 2	37	4.7	27.3	15.0	12.1	.12
Jan. 13–19	18	4.7	17.3	4.1	13.1	.09
Jan. 27–Feb. 2	37	4.7	25.3	12.7	12.5	.07
Feb. 10–16	20	4.4	15.8	3.4	12.3	.07

TABLE XXII.—RELATION BETWEEN NITROGEN AND PHOSPHORUS EXCRETION.

DATE.	NITROGEN.		DAILY INCOME AND OUTGO OF PHOSPHORUS.					
	Fed daily.	Outgo daily.	Fed.	Soluble fed.	In-organic fed.	Total ex-creted.	Soluble ex-creted.	In-organic creted.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
Dec. 27–Jan. 2....	226	217	37.3	15.8	4.7	42.0	30.4	27.2
Jan. 13–19........	270	266	18.2	8.8	4.7	30.2	20.3	17.2
Jan. 27–Feb. 2....	229	212	37.3	15.8	4.7	39.8	28.4	27.2
Feb. 10–16........	279	263	20.2	8.8	4.4	29.2	18.6	15.7

TABLE XXIII.—EFFECTS OF THE INGESTION OF PHOSPHORUS COMPOUNDS UPON THE COMPOSITION OF THE MILK.

DATE.	Total phosphorus fed daily.	IN THE MILK.				
		Proteids.	Casein.	Fat.	Sugar.	Solids.
	Grms.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Dec. 27–Jan. 2.............	37	2.58	2.09	2.78	5.47	10.87
Jan. 13–19..................	18	2.77	2.19	2.74	5.49	11.00
Jan. 27–Feb. 2..............	37	2.66	2.21	2.83	5.67	11.08
Feb. 10–16..................	20	2.81	2.29	2.67	5.49	10.97

TABLE XXIV.—EFFECTS OF THE INGESTION OF PHOSPHORUS COMPOUNDS UPON THE YIELD OF MILK AND MILK SOLIDS AND UPON THE EXCRETION OF URINE.

DATE.	Phosphorus fed daily.	Yield milk daily.	DAILY YIELD MILK SOLIDS.			Weight urine, daily.
			Casein nitrogen	Fat.	Total. solids.	
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
Dec. 27–Jan. 2..........	37	16715	55	464	1812	3600
Jan. 13–Jan. 19..........	18	17620	61	482	1935	5752
Jan. 27–Feb. 2..........	37	16768	58	462	1858	4528
Feb. 10–Feb. 16..........	20	16960	61	452	1860	5468

DISCUSSION OF RESULTS.

The data furnished by this experiment appear to justify the following statements:

1. *The comparative nutritive value of the rations.*—The quantity of digestible dry matter fed daily varied in the several periods from 15.7 pounds to 16.9 pounds, the amounts ingested in the two high phosphorus periods being not greatly unlike what was eaten in the two low phosphorus periods. The quantities of digestible protein consumed in the several periods varied from 1.8 pounds daily to 2.8

pounds. The low phosphorus ration carried in all cases more digestible protein than did the other ration. The supply of nutrients was abundant in all periods. (See Table 13.)

2. *The amounts and forms of ingested phosphorus in the two rations.*—The quantities of phosphorus compounds which the two rations carried were not so greatly unlike as was the case in the first experiment. In both periods of the higher phosphorus feeding the amount of ingested phosphorus was 37.3 grams, while in the other two periods the quantity was 18.2 grams and 20.2 grams respectively. The proportions of the various classes of phosphorus compounds in the two rations were quite unlike what was found in the first experiment. Approximately 57 per ct. existed in forms insoluble in dilute hydrochloric acid or what we believe to be chiefly nucleins and nucleo-proteids. Thirty per ct. existed as soluble organic phosphorus in ration 1 and from 23 to 24 per cent. in ration 2. The inorganic phosphorus remained practically a constant quantity in the two rations, viz. 4.7 grams daily. This experiment was also unlike the first one in that the two rations differed chiefly in the quantities of insoluble phosphorus compounds which they carried rather than in the proportions of phytin. (See Tables 18–21.)

3. *The relation in amounts and forms of the ingested and the outgoing phosphorus.*—In no period was the quantity of ingested phosphorus equal to the outgoing amount. With ration 1 this deficiency was from 2.5 to 4.7 grams daily, while with ration 2 it was 12 grams in one period and 9 grams in the other. These data furnish another illustration of the fact that a cow is able to make good a phosphorus deficiency in the ration from the store contained in her body. We regard it as unfortunate that in this experiment we were not able to feed an excess of phosphorus compounds in the high phosphorus ration.

In regard to the proportionate distribution of phosphorus compounds in the ingesta as compared with the egesta, the facts are essentially similar to what was found in the first experiment. The quantity of excreted phosphorus increased and decreased with the amount fed, and as in the first experiment the variations in the outgoing amount were found to occur chiefly with the proportions of inorganic forms in the egesta. (See Tables 18–21.)

4. *Distribution of outgoing phosphorus compounds in the milk and egesta.*—The variations of the outgoing phosphorus are again found to occur almost wholly in the feces through a rise or fall of inorganic forms. This second experiment furnishes no evidence of changes in the distribution of other forms of phosphorus in the milk and egesta, due to variations in the quantities of phosphorus compounds in the ration. (See Tables 19–21.)

5. *Physiological effects due to variations in the phosphorus bodies of the two rations.*—There is a marked difference between this experiment and the first one in the extent, at least, of the physiological disturbances observed. The results are alike in that the amount of phosphorus excretion had no effect upon the storage or excretion of nitrogen. The results are unlike in the influence of changing rations upon the health of the animal and the condition of the feces. Nothing like constipation was observed, nor was there any marked change in the condition or color of the fecal discharge.

There was a perceptible, though not marked, variation in the volume of urine in the several periods, the change being in the reverse direction from that observed in the first experiment. In other words, the volume of urine was larger with the smaller phosphorus supply. The fact that the low phosphorus ration in this experiment carried the larger amount of digestible protein may in part account for this increase in the volume of urine.

An examination of the figures shows that the volume of milk was somewhat larger during the low phosphorus period and that there was a small but perceptible lowering for a time, at least, of the percentage of fat in the milk. These changes are small, however, and not nearly as emphatic as was the case in the first experiment. (See Tables 22-24.)

6. *Effect of the two rations upon production.*—While the production of total milk solids, as well as of casein and fat, varied somewhat in the different periods, the data do not consistently show that these changes were due to the influence of the food. (See Table 24.)

EXPERIMENT III.

This was a repetition of the experiment involving variations in the phytin content of the rations.

In the experiment of 1904 (Experiment 1), in which the rations were made to differ chiefly by the substitution of washed for unwashed wheat bran, thus causing very large variations in the phytin content of the food, certain very remarkable results were obtained, which should not be accepted as final without substantiation through further observations. Consequently it was decided to repeat the phytin experiment, and as the animal used in Experiment 2 had become accustomed to experimental conditions and to the washed bran ration, it was decided to continue work with her.

THE EXPERIMENTAL ANIMAL.

The animal has been described in the details given for the nucleo-proteid experiment. (Experiment 2.)

MANAGEMENT OF THE EXPERIMENT.

The management of this experiment was similar in all its details to that of the two former experiments, other than some differences which may have occurred in the sequence of the feeding periods.

THE RATIONS.

The components of the ration, outside of the bran, were oat straw, rice and wheat gluten. To these basal feeds washed bran was added in certain periods and unwashed bran in others. In the first experiment when the change was made from the washed bran to the unwashed bran ration, hominy feed was substituted for the rice meal. In this experiment this substitution did not take place but the rice meal was continued in both rations. By this arrangement the variations in the nucleo-proteid content of the rations were not emphasized by the substitution of hominy meal for the rice. As in the other experiments the protein supply was regulated by varying the quantity of wheat gluten.

CHARACTER AND SEQUENCE OF THE RATIONS.

Reference to the nucleo-proteid experiment shows that the cow during the last period of that experiment was fed the washed

bran ration. It was necessary, therefore, that in the first period of this second phytin experiment there should be fed a ration containing unwashed bran.

Ration 1.—At noon on February 16 the cow was suddenly changed to the ration containing the unwashed bran. She consumed the entire ration on the 16th and two portions of it on the 17th and refused the third portion. It was thought that possibly the quality of the bran was the cause of this refusal to eat, and, consequently, a bran of superior quality procured from a nearby mill, was tried but with no avail. The cow continued to refuse the ration during the 18th and 19th. On the 20th she was offered small portions of washed bran which were eaten with a keen appetite. It was clearly indicated that the sudden introduction into the ration of certain bran constituents was responsible for the change in the animal's appetite. Her health did not seem to be impaired. She was not feverish and while her feces had become somewhat softened in consistency, there was nothing in her outward appearance that indicated an abnormal condition of health. During this time of impaired nutrition the flow of milk was considerably lessened, as was the excretion of feces and urine.

Ration 2.—Fed from noon February 20 to the morning of February 25th. The change back to the washed bran ration was sudden, the entire daily portion being wholly consumed. A normal milk flow was soon re-established.

Transition period.—This was begun at noon February 25 and was completed on the morning of March 9. An attempt was made to transfer the animal from ration 2 to ration 1 by the daily substitution of two pounds of unwashed bran for an equivalent weight of washed bran, with an accompanying daily decrease of one-half pound of wheat gluten. This method appeared to be successful up to the point where the cow was receiving 6 pounds of unwashed bran. The first day that 8 pounds of unwashed bran was fed the ration was not wholly consumed. The next day the cow again refused to eat and it became necessary to place her back on a ration containing 4 pounds of unwashed bran and 6 pounds of the washed. This mixture was heartily eaten and from this point the food was slowly changed to the high phytin ration by the daily addition of 1 pound of unwashed bran and some days only one-half pound, with

a corresponding decrease in the washed bran. In this way the transition was successfully accomplished.

Ration 1.—Fed from noon March 9 to the morning of March 19.

Transition period.—From noon March 19 to the morning of March 23.

During this time two pounds of washed bran were substituted daily for 2 pounds of the unwashed and when the ration contained 6 pounds of washed bran, one-half pound of wheat gluten was added daily to supply the deficiency in protein. At the end of this period the feces had become hard and dry.

Ration 2.—From noon March 23 to the morning of April 10.

Ration 1.—At noon April 10, the cow was suddenly transferred to ration 1 which she ate heartily for two days and then refused further portions. She was then placed on a ration containing 4 pounds of unwashed bran and 6 pounds of washed bran, which she completely consumed on April 12.

Transition period.—From noon April 12 to the morning of April 18.

Starting with the ration which was fully consumed on April 12, a change was made gradually to ration 1 by the daily substitution of 1 pound of unwashed bran for an equivalent quantity of the washed, the wheat gluten being decreased by one-half pound.

Ration 1.—From noon April 18 to the morning of May 2.

Transition period.—This occupied from noon May 2 to the morning of May 6.

This transition was accomplished by the daily substitution of two pounds of washed bran for an equal weight of the unwashed with a daily increaase during the entire period of one-half pound of wheat gluten.

Ration 2.—From noon May 6 to the morning of June 4. After June 4 the animal was placed with the Station herd and slowly brought to the ordinary milk ration.

During this experiment a sudden change from the high phytin ration to the one containing washed bran was found to be inadvisable. Abundant evidence was accumulated concerning the drier condition and firmer consistency of the feces when the washed bran was fed, apparently establishing beyond question the comparatively laxative effect of the whole wheat bran.

NUMERICAL RESULTS OF THE EXPERIMENT.

The data of this experiment are summarized in the following tables, the arrangement of which is entirely similar to that followed in discussing the other experiments.

Table 25.—The rations fed.

Table 26.—The composition of the feeding stuffs used.

Table 27.—Quantities and percentages of digestible nitrogen and dry matter fed.

Table 28.—Percentage daily composition of the milk with both high and low phosphorus ingestion, including two transition periods.

Table 29.—Percentages of various forms of phosphorus in the milk.

Table 30.—Total phosphorus balances.

Table 31.—Distribution and balances of nucleo-phosphorus.

Table 32.—Distribution and balances of soluble phosphorus compounds.

Table 33.—Distribution and balances of inorganic phosphorus compounds.

Table 34.—Relation between nitrogen and phosphorus excretion.

Table 35.—Effects of the ingestion of phosphorus compounds upon the composition of the milk.

Table 36.—Effects of the ingestion of phosphorus compounds upon the yield of milk and milk solids and upon the excretion of urine.

TABLE XXV.—THE RATIONS FED.

INGREDIENTS.	Ration No. I.	INGREDIENTS.	Ration No. II.
Oat straw	10 lbs.	Oat straw	10 lbs.
Bran	10 "	Washed bran	10 "
Rice meal	7 "	Rice meal	7 "
Wheat gluten	1½ "	Wheat gluten	2 "
Total	28½ lbs.	Total	29 lbs.

TABLE XXVI.—THE COMPOSITION OF THE FEEDING STUFFS USED.

FEEDS.	Water.	Protein.	Fat.	PHOSPHORUS.		
				Total.	Soluble.	Inorganic.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Oat straw	10.62	5.74	1.80	.198	.132	.088
Bran	9.06	14.25	4.40	1.27	.899	.00
Washed bran	8.44	11.12	4.19	.145	.050	.00
Rice meal	12.67	8.37	.36	.084	.007	.00
Wheat gluten	7.41	85.5	1.56	.220	.032	.00

TABLE XXVII.—QUANTITIES AND PERCENTAGES OF DIGESTIBLE NITROGEN AND DRY MATTER FED.

DATE.	Phosphorus fed daily.	DRY MATTER DAILY.			NITROGEN DAILY.		
		Fed.	In feces.	Digested.	Fed.	In feces.	Digested.
	Grms.	*Grms.*	*Grms.*	*Per ct.*	*Grms.*	*Grms.*	*Per ct.*
March 12–18	77	11 484	3 523	69.3	284.7	83.9	70.5
March 30–April 5	16	11 805	4 282	63.7	269	82.6	69.3

TABLE XXVIII.—PERCENTAGE DAILY COMPOSITION OF THE MILK WITH BOTH HIGH AND LOW PHOSPHORUS INGESTION INCLUDING TWO TRANSITION PERIODS.

Date.	Phosphorus fed daily.	In milk.					Date.	Phosphorus fed daily.	In milk.				
		Proteids.	Casein.	Fat.	Sugar.	Solids.			Proteids.	Casein.	Fat.	Sugar.	Solids.
	Grms.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.		Grms.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
March 16	77	3.27	2.69	3.40	5.58	12.25	April 30	77	3.11	2.58	3.80	5.27	12.18
17	77	3.03	2.60	3.25	5.78	12.06	May 1	77	3.26	2.75	3.75	5.43	13.44
18	77	2.93	2.33	3.25	5.42	11.60	2	65	3.21	2.63	3.80	5.36	12.37
19	65	2.92	2.37	3.20	5.34	11.46	3	54	3.11	2.57	3.65	5.46	12.22
20	54	2.91	2.38	3.30	5.35	11.56	4	43	3.09	2.54	3.80	5.37	12.26
21	43	3.03	2.48	3.40	5.29	11.72	5	31	3.16	2.66	3.55	5.35	12.06
22	31	3.00	2.47	3.20	5.44	11.64	6	16	3.26	2.71	3.65	5.30	12.21
23	20	3.06	2.47	3.15	5.46	11.67	7	16	3.24	2.63	3.45	5.38	12.07
24	20	2.94	2.44	2.95	5.61	11.50	8	16	3.34	2.75	3.00	5.33	11.67
25	18	3.04	2.48	3.25	5.43	11.72	9	16	3.32	2.68	3.75	5.20	12.27
26	18	2.96	2.39	3.15	5.44	11.55	10	16	3.18	2.51	3.35	5.23	11.76
27	18	2.96	2.41	3.20	5.40	11.56	11	16	3.29	2.70	3.20	5.32	11.81
28	18	3.03	2.44	3.15	5.37	11.55	12	16	3.30	2.72	3.15	5.30	11.75
29	18	3.01	2.44	3.20	5.40	11.61	13	16	3.29	2.72	3.10	5.39	11.78
30	16	3.03	2.47	3.20	5.47	11.70	14	16	3.24	2.65	3.25	5.51	12.00
							15	16	3.22	2.63	3.10	5.29	11.61
							16	16	3.16	2.60	3.30	5.67	12.13
							17	16	3.15	2.63	3.10	5.58	11.83

TABLE XXIX.—PERCENTAGES OF VARIOUS FORMS OF PHOSPHORUS IN THE MILK.

DATE.	Total phosphorus fed.	PHOSPHORUS IN MILK.			DATE.	Total phosphorus fed.	PHOSPHORUS IN MILK.		
		Total.	Soluble.	Inorganic.			Total.	Soluble.	Inorganic.
	Grms.	*Per ct.*	*Per ct.*	*Per ct.*		*Grms.*	*Per ct.*	*Per ct.*	*Per ct.*
March 16	77	.101	.076	.071	March 24	20	.104	.083	.077
17	77	.101	.077	.074	25	18	.104	.083	.074
18	77	.101	.078	.069	26	18	.109	.082	.077
19	65	.106	.084	.076	27	18	.109	.085	.078
20	54	.107	.083	.076	28	18	.107	.083	.079
21	43	.105	.085	.078	29	18	.105	.084	.076
22	31	.100	.085	.075	30	16	.104	.082	.081
23	20	.110	.085	.077					

TABLE XXX.—TOTAL PHOSPHORUS BALANCES.

DATE.	DAILY INCOME AND OUTGO OF PHOSPHORUS.				
	Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*
March 12–18................	77	68.4	43.5	14.7	10.17
March 30–April 5............	16	26.8	10.9	15.8	.08

TABLE XXXI.—DISTRIBUTION AND BALANCES OF NUCLEO-PHOSPHORUS.

DATE.	Total phosphorus fed daily.	DAILY INCOME AND OUTGO OF FIXED PHOSPHORUS.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
March 12–18................	77	23.2	13.4	9.9	3.5	.00
March 30–April 5............	16	9.6	9.4	6.1	3.3	.00

TABLE XXXII.—DISTRIBUTION AND BALANCES OF SOLUBLE ORGANIC PHOSPHORUS COMPOUNDS.

DATE.	Total phosphorus fed daily.	DAILY INCOME AND OUTGO OF SOLUBLE ORGANIC PHOSPHORUS.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
March 12–18................	77	50.2	1.58	.53	1.05	.00
March 30–April 5............	16	2.6	1.86	.69	1.17	.00

TABLE XXXIII.—DISTRIBUTION AND BALANCES OF INORGANIC PHOSPHORUS COMPOUNDS.

DATE.	Total phosphorus fed daily.	DAILY INCOME AND OUTGO OF INORGANIC PHOSPHORUS.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
March 12–18................	77	4.0	53.4	33.1	10.2	10.17
March 30–April 5............	16	4.2	15.5	4.2	11.2	.08

TABLE XXXIV.—RELATION BETWEEN NITROGEN AND PHOSPHORUS EXCRETION.

DATE.	NITROGEN.		DAILY INCOME AND OUTGO OF PHOSPHORUS.					
	Fed daily.	Outgo daily.	Fed.	Soluble fed.	Inorganic fed.	Total excreted.	Soluble excreted.	Inorganic.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
March 12–18......	284	241	77	54	4	68	45	43
March 30–April 5..	269	246	16	6.8	4	26.8	17.3	15.4

TABLE XXXV.—EFFECTS OF THE INGESTION OF PHOSPHORUS COMPOUNDS UPON THE COMPOSITION OF THE MILK.

DATE.	Total phosphorus fed daily.	IN THE MILK.				
		Proteids.	Casein.	Fat.	Sugar.	Solids.
	Grms.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
March 12–18	77	3.07	2.53	3.28	5.56	11.91
March 30–April 5	16	3.05	2.45	3.09	5.46	11.59
April 24–May 1	77	3.22	2.66	3.73	5.47	12.41
May 29–June 4	16	3.27	2.75	3.29	5.50	12.07

TABLE XXXVI.—EFFECTS OF THE INGESTION OF PHOSPHORUS COMPOUNDS UPON THE YIELD OF MILK AND MILK SOLIDS AND UPON THE EXCRETION OF URINE.

DATE.	Phosphorus fed daily.	Yield milk daily.	DAILY YIELD MILK SOLIDS.			Weight urine daily.
			Casein nitrogen.	Fat.	Total solids.	
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
March 12–18	77	14606	58	478	1739	9433
March 30–April 5	16	14899	57.6	459	1726	5482
April 24–May 1	77	12686	53	473	1575	
May 29–June 4	16	11917	51.7	392	1438	

DISCUSSION OF RESULTS.

The results secured in this experiment are in the main confirmatory of those obtained in Experiment 1.

1. *The comparative nutritive value of the rations.*—Both rations supplied an abundance of digestible nutrients. The dry matter digested daily from ration 1 was 17.5 pounds and from ration 2, 16.5 pounds, the amounts of digestible protein being 2.8 pounds and 2.6 pounds respectively. The difference between these two rations is not sufficient to account in any way for the physiological and other effects observed. (See Table 27.)

2. ***The amounts and forms of ingested phosphorus in the two rations.***—Ration 1 carried 77 grams of phosphorus and ration 2, 16 grams. Of the phosphorus in ration 1, 65 per ct., or 50.2 grams, consisted of soluble organic phosphorus compounds, which was practically all phytin. In ration 2 only 2.6 grams of phosphorus was found in soluble organic combinations. The nucleo-proteid phosphorus in ration 1 amounted to 23.2 grams or 30 per ct. of the whole, and in ration 2 9.6 grams or 60 per ct. of the whole, the larger amount of this form of phosphorus in ration 1 being due to the difference in the composition of the unwashed and washed bran. As in the former experiments, the food supply

of inorganic phosphorus was small and similar in the two rations. These figures make it evident that the quantities and proportions of phosphorus compounds in these two rations were quite similar to what was found in the rations used in experiment 1. (See Tables 31-33.)

3. *The relation in amounts and forms of the ingested and the outgoing phosphorus.*—The comments offered under this heading in discussing experiment 1 could be repeated here in the main as accurately characterizing the outcome of this experiment. Briefly stated, the amount of excreted phosphorus rose and fell with the food supply; during the feeding of the high phytin ration phosphorus storage occurred while with the low phytin ration the outgo of phosphorus was an average of 10.8 grams per day more than the income, a condition which the animal sustained through one period of 30 days without serious effects; the phytin phosphorus and that in the unused nucleo-proteids was practically all reduced to inorganic forms; the variations in the outgoing phosphorus were chiefly changes in the proportions of the inorganic salts of this element and finally no evidence was secured showing that there was any synthesis of the phosphorus-bearing proteids. (See Tables 30-33.)

4. *Distribution of outgoing phosphorus compounds in the milk and egesta.*—Again the outcome of this experiment is similar to what was observed with the first one, viz., the rise and fall of phosphorus compounds in the egesta occurred chiefly in the feces, though to a considerable extent in the urine. When the larger amount of phosphorus compounds was fed, there was a marked increase in the inorganic phosphorus compounds of the feces and urine. Casein secretion was not affected by the phosphorus supply and the proportions of organic phosphorus bodies in the egesta appeared not to be affected by the supply of these in the food. (See Tables 28 and 31-33.)

5. *Physiological effects due to variations in the phosphorus bodies of the two rations.*—A larger proportion of ration 1 was digested than of ration 2, due undoubtedly to the fact that the washed bran was less digestible than the unwashed. Practically the same proportion of nitrogen was digested from the two rations, but there was a somewhat greater storage of nitrogen compounds from ration 1 than from ration 2, a result evidently independent

of the phosphorus supply. The withdrawal of the phytin from the ration again had the effect of causing marked constipation, although in this experiment, because of the precautions that were taken in arranging the transition periods, it was not found necessary to administer a purgative at any time. The laxative influence of the phytin seems to be well established, for it does not appear probable that in washing the bran other compounds of a laxative character were taken out.

The volume of urine was greatly decreased when the washed bran was substituted for the unwashed, the quantity with the high phytin ration being 72 per cent. larger than when the phytin was withdrawn. This result is fully as marked in this experiment as it was in the former one.

It is very clear that in this experiment, as in the first one, the excretion of nitrogen bears no relation to the phosphorus outgo, a fact to which reference will be made later in our discussion.

The average weights of milk produced as given for the several periods do not show any influence arising from changes in the amounts of phosphorus compounds fed. When, however, we come to consider the records of milk flow immediately succeeding the change to the washed bran ration, the effect of the change is made very evident. The following table shows the milk yield through a transition period beginning March 16th and ending March 24th.

TABLE XXXVII.—YIELDS OF MILK DURING A TRANSITION PERIOD FROM HIGH TO LOW PHOSPHORUS RATION.

DATE.	Total phosphorus fed.	Daily yield milk.	DATE.	Total phosphorus fed.	Daily yield milk.
	Grms.	*Grms.*		*Grm.*	*Grms.*
March 15	77	14429	March 20	43	16202
16	77	14088	21	31	15167
17	77	14500	22	19.8	15181
18	65	15252	23	19.8	15365
19	54	15521	24	19	15408

The above figures show an unmistakable influence of the change in the phytin supply.

The influence of a change in the rations upon the composition of the milk, that is, upon the percentage of fat, is not as marked as in the first experiment. In Table 28, where the daily composition of the milk is detailed, covering a period from March 16th to March 30th, during which time the ingested phosphorus

was diminished from 77 grams daily to 16 grams, there is shown a small but unmistakable lowering of the percentage of fat. In this period from April 30 to May 17, when a similar reduction was made in the ingested phosphorus, the effect upon the fat percentage is much more marked, amounting to from six to seven-tenths per ct. During the lowering of the quantity of phosphorus fed the decrease in the fat content of the milk was a progressive one. In this period there did not appear to be a tendency, as was observed in Experiment 1, towards the restoration of the fat content to its original proportions. The decrease in the percentage of milk solids is almost entirely accounted for by the decrease in the proportion of fat. (See Tables 27, 30-36.)

6. *Influence of the two rations upon production.*—During this experiment the yield of total milk solids and of casein gradually diminished without any apparent relation between production and the character of the rations. The yield of milk fat was perceptibly lessened during the low phytin periods. (See Table 36.)

7. *Oestrum period.*—This animal did not show the marked disturbance in this direction that was observed with cow 1. On the 20th of February, during the time she was passing from a low phytin ration to the one rich in that compound, the oestrum failed to appear. This was the only instance of the kind recorded with this animal. It was thought that perhaps a withdrawal of phytin from the ration for a long time would produce a result similar to that which occurred with cow 1, but during a thirty-day period of low phosphorus feeding, and afterwards, the oestrum regularly occurred. The animal afterwards became pregnant.

GENERAL DISCUSSION OF THE THREE EXPERIMENTS.

The data obtained from these three experiments involving the use of two animals, consistently support the following conclusions. Certain of the facts observed, which, with others, are here briefly summarized, agree with observations made by other investigators.

1. The amount of outgoing phosphorus rose and fell with the quantity supplied in the food, though within narrower limits. When the phosphorus supply was abundant there was a storage of this element in the bodies of the animals, but during prolonged periods in which the supply of phosphorus was deficient there was withdrawn from the body store about 10 grams daily in several periods.

2. Through catabolic changes the phosphorus of the phytin and that of the unused digested nucleo bodies was reduced to inorganic combinations, and was excreted chiefly in the feces, though to a small extent in the urine.

(The phosphorus of the urine is calculated wholly as inorganic. While we may not be justified in doing this, attempts to separate phytin or other organic forms of phosphorus from the urine by the methods employed in all the other work failed entirely. Whatever error is introduced by this method of calculation must certainly be small.) Further evidence of catabolic metabolism of phosphorus compounds is found in the fact that the inorganic phosphates of the milk were from three to five times greater in quantity than the total amount of such compounds in the food. The rise and fall in the amounts of outgoing phosphorus compounds occurred almost wholly with the inorganic salts found in the egesta. The organic phosphorus bodies of the egesta were but little affected, if at all, by the proportions of phosphorus compounds in the food. Variations in the phosphorus supply appeared not to modify the appropriation of this element by the milk.

3. No relation whatever appears to exist between nitrogen excretion and phosphorus excretion.

4. It is shown without question that the physiological effect of the two rations, due to the withdrawal from the bran of such compounds as were soluble in slightly acidulated water, differed to a marked degree. With the washed bran ration as compared with the one containing the unwashed bran, the following differences were observed.

a. Drier and much firmer feces with the washed bran ration, accompanied by a constipated condition, requiring in some cases the use of a purgative.

b. A marked disturbance of appetite (in Experiment 3) when a sudden change was made from the washed bran ration to the one containing the unwashed bran, indicating some specific physiological influence of the compound or compounds removed from the bran by leaching.

c. A greatly reduced flow of urine following a change from the unwashed bran to the washed bran ration, the reverse taking place when a reverse change was made.

d. An increase in the flow of milk consequent upon the withdrawal from the ration of the phytin and other water-soluble constituents of bran.

e. A reduction, sometimes large, in the percentage of fat in the milk consequent upon the withdrawal from the ration of phytin and other water-soluble constituents of bran.

f. A decreased production of butter-fat during the period the washed bran ration was fed, notwithstanding a somewhat increased flow of milk.

g. The entire cessation of the oestrum period with cow 1 and a temporary disturbance of this period with cow 2.

h. The foregoing effects were observed chiefly in experiments 1 and 3, in which the difference in the phosphorus content of the two rations was brought about by leaching the phytin and other soluble compounds out of the wheat bran. In experiment number 2 where the phytin content was small and remained unchanged, similar physiological influences were not sufficiently marked to place much emphasis upon them.

To what cause shall these physiological influences be attributed? —We now come to the important question as to what compound or compounds in the rations may be regarded as the exciting cause of the physiological influences observed. It is doubtful whether our data justify definite conclusions, but the situation may be somewhat elucidated, perhaps, by a discussion of certain factors entering into the problem. There are several possibilities to be considered:

1. The difference in effect of the two rations may be due to the larger supply of phosphorus in one ration without reference to the form of the combination.

2. The compound known as phytin may have specific physiological influences in several directions.

3. The withdrawal from the ration of the basic compounds with which phosphorus is associated in the compound phytin may explain wholly or in part the peculiar physiological influences observed.

In discussing the first point it should be stated that experiment 2 was planned with the hope that by eliminating the phytin and varying the quantity of other phosphorus compounds light would be thrown upon the question of the influence of the supply of organic phosphorus bodies without reference to their nature. The

experiment was not entirely satisfactory. In no period was the phosphorus income equal to the outgo and it is not clear what would have been the result had the two rations been as fully differentiated in their phosphorus content as was the case in experiments 1 and 3. However, there are indications, not to be ignored, that the two rations in the nucleo-proteid experiment had a somewhat unlike effect upon the flow and composition of the milk.

The other two points must be considered together. The problem here involved is whether, if phytin exerts the physiological effects observed, its influence is to be attributed to its acid phosphorus radical or to the basic portion, calcium, magnesium and potassium, or to the organic compound as an entity. The question was then raised in the progress of the work whether the withdrawal from the bran, by leaching, of the bases calcium, magnesium and potassium, might not so influence the supply of the compounds of these elements in the rations as to cause results that otherwise would be attributed to the phosphorus supply.

Analyses of both the unwashed and washed bran show that the leaching removed the greater portion of the magnesium and potassium compounds and but very little of the calcium compounds. The following figures comfirm this statement:

TABLE XXXVIII.—INORGANIC CONSTITUENTS OF BRAN BEFORE AND AFTER LEACHING.

	P.	CaO.	MgO.	K_2O.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*
Whole bran	1.42	.182	.894	1.58
Washed bran	.145	.380	.162	.684

The marked difference in the composition of the two kinds of bran, as indicated above, very naturally suggested the inquiry as to whether the supply of certain bases in the washed bran ration might not be insufficient. Consequently the amounts of the ingested and outgoing calcium, magnesium and potassium oxides were determined for two periods in experiment 3, one March 14 to 17, inclusive, during which time unwashed bran was fed; and March 30 to April 2, inclusive, this being part of a washed bran period. The results of this inquiry are given in the following tables:

INCOME AND OUTGO OF CERTAIN BASES.

TABLE XXXIX.—CaO BALANCE.

Date.	Phosphorus fed daily.	Daily income and outgo CaO.					Date.	Phosphorus fed daily.	Daily income and outgo CaO.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.			Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.		Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
March 14	77	31.7	36.8	11.0	25.2	0.6	March 30	16	39.4	59.9	23.3	27.1	9.5
15	77	31.7	38.6	13.0	25.0	0.6	31	16	39.4	56.0	25.0	26.3	4.7
16	77	31.7	37.7	12.1	25.1	0.5	April 1	16	39.4	60.0	21.9	27.3	10.8
17	77	31.7	36.7	12.4	23.9	0.4	2	16	39.4	58.0	25.8	26.0	6.4

TABLE XL.—MgO BALANCE.

Date.	Total phosphorus fed.	Daily income and outgo MgO.					Date.	Total phosphorus fed.	Daily income and outgo MgO.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.			Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.		Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
March 14	77	68.3	45.1	36.0	3.6	5.5	March 30	16	24.2	18.6	11.7	3.5	3.4
15	77	68.3	51.3	42.6	3.2	5.5	31	16	24.2	17.9	12.7	3.4	1.8
16	77	68.3	49.7	40.7	3.1	5.9	April 1	16	24.2	14.2	7.0	3.5	3.7
17	77	68.3	46.8	39.8	3.2	3.8	2	16	24.2	16.6	11.7	2.9	2.0

TABLE XLI.—K_2O BALANCE.

Date.	Total phosphorus fed.	Daily income and outgo K_2O.					Date.	Total phosphorus fed.	Daily income and outgo K_2O.				
		Fed.	Total outgo.	In feces.	In milk.	In urine.			Fed.	Total outgo.	In feces.	In milk.	In urine.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.		Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
March 14	77	166.7	140.7	49.8	28.1	62.8	March 30	16	113.5	108.2	32.4	31.2	44.6
15	77	166.7	162.0	64.6	26.1	71.3	31	16	113.5	85.4	35.1	29.7	20.6
16	77	166.7	163.5	60.3	27.8	75.4	April 1	16	113.5	81.8	22.9	32.7	26.2
17	77	166.7	146.7	54.7	26.4	65.6	2	16	113.5	81.6	37.9	31.2	12.5

The facts displayed in the above figures are very suggestive. It appears that in both periods the animal excreted more calcium oxide than she received, and the somewhat surprising result is shown that the animal gave up from her body store much the larger amount of calcium compounds when the income of phosphorus was less than the outgo. This fact will be considered later.

The supply of magnesium and potassium compounds was greater in the food in both periods than was the amount excreted. In fact, there was a storage of magnesium in both periods and especially of potassium in the period of low-phosphorus feeding. It is not easy to draw from these facts the conclusion that the unlike physiological influence of the two rations is due to a withdrawal from the bran of the bases under consideration. In both periods there was a calcium balance against the animal and an apparently sufficient supply of both magnesium and potassium. Our knowledge of materia medica suggests, of course, that the larger supply of magnesium compounds in ration 1 may have had some influence of a laxative character and it is also conceivable that the greater amount of excreted potassium compounds may have increased the flow of urine. Outside of these suggestions it is difficult to even theorize as to why the extent of the supply of these bases should explain the physiological influences that are under discussion. The authors are inclined to the view that the compound known as phytin exerts specific physiological influences.

The supposed laxative effect of whole wheat bread.—It is generally believed, how correctly is not definitely established, that whole wheat bread is a desirable food for persons of a constipated habit. This supposed influence is usually attributed to the effect of the coarser material upon the peristaltic action of the intestines. The outcome of this investigation very naturally suggested the thought that if whole wheat bread really possesses the laxative properties assigned to it, this may be due to the amount of phytin it carries rather than to its mechanical condition. With this point in view, analyses were made of the milling products from a par-

ticular lot of wheat, which was ground at a nearby mill. These analyses are given in the table below:

TABLE XLII.—PHOSPHORUS CONTENT OF WHEAT AND ITS MILLING PRODUCTS.

	Phosphorus.		Phosphorus.
	Per ct.		*Per ct.*
Whole wheat	.378	1st middlings*	.071
Bran	1.28	2nd "	.079
Middlings (ships)	.857	3rd "	.091
Germ	.765	Germ roll flour	.074
Straight flour	.089	Tailings or last roll	.135
1st break flour	.089	Tailings reel	.134
2nd " "	.088	Bran duster flour	.196
3rd " "	.088	Low grade flour	.166

* "Middlings" is millers' term for fine flours.

It is evident, as is well known, that the phosphorus compounds of the wheat kernel are found mainly in the outer coatings and germ from which are derived the bran and middlings. As the bran phosphorus is mostly contained in the compound phytin, it is self-evident that this substance exists in much larger proportion in the whole wheat bread than in fine flour. These statements are offered as suggesting a problem for further study.

A pharmacological study of the compound phytin.—In view of the possible pharmacological properties of this compound, as indicated in these experiments, it was thought to be very desirable that experienced investigators should undertake a study of its physiological influence. Correspondence was entered into with Dr. R. H. Chittenden of Yale University and he very kindly consented to undertake pharmacological observations with this substance. There was prepared, therefore, in our laboratory the anhydrooxy-methylenediphosphoric acid, which is phytin freed from its bases, a quantity of which was sent to Dr. Chittenden. We understand that the studies indicated are now in progress under the direction of Dr. L. B. Mendel.

The increased flow of urine, caused by feeding the unwashed bran ration.—Several points need consideration in this connection. Marked changes in temperature undoubtedly have an influence on urine secretion but as both of these animals stood in a room which was warmed to the point of comfort by artificial means, this factor hardly needs consideration. It has already been made clear that

the larger urine excretion was not correlated with an increased nitrogen outgo.

The amount of water drank would certainly exert some influence. In order to determine whether any relation existed between the water taken and urine excretion, the following table has been prepared showing the average daily quantities of water consumed during the periods for which other averages have been given.

TABLE XLIII.—RELATION OF FLOW OF URINE TO AMOUNT OF WATER DRANK.

Cow 1.				Cow 2.			
PERIOD.	Phosphorus fed.	Water drank daily.	Weight of urine daily.	PERIOD.	Phosphorus fed daily.	Water drank daily.	Weight of urine daily.
	Grms.	*Lbs. oz.*	*Grms.*		*Grms.*	*Lbs. oz.*	*Grms.*
March 11-16...	12.8	75- 9	4974	Dec. 27-Jan. 2.	37.3	77-15	3600
April 12-18....	78.7	69-10	10555	Jan. 13-19....	18.2	88-	5782
Apr. 28-May 1.	16	55- 6	9560	Jan. 27-Feb. 3	37.3	78- 5	4528
May 9-15.....	83.3	97-12	12723	Feb. 10-16....	20.2	85-12	5468
May 22-26....	21.4	72-10	10147	March 12-18..	77	85- 8	9433
				Mar. 30-Apr. 5	16	79- 9	5482

It would not be logical to conclude from the figures of the above table that the variations in the volume of urine are caused by variations in the water supply. If the whole case rested on a comparison between the period May 9 to 15 and the periods preceding and following, a consistent relation would be established, but on the other hand a comparison of the period, March 11 to 16, with April 12 to 18, and of February 10 to 16 with March 12 to 18, gives us opposing evidence.

The effects produced upon the volume and composition of the milk.—A definite explanation of the unlike influences exerted by the different rations upon the volume and composition of milk is not now possible. It may be that the volume relations of both urine and milk are affected by the osmotic tensions induced by the presence of certain salts.

The work of Herter (See page 59) showing that an insufficient fat supply in the food of young animals depresses the assimilation of phosphoric acid, is suggestive in this connection. These experiments show a reverse relation in that the elaboration of butter-fat is apparently lessened by an insufficient phosphorus supply.

The question naturally presents itself as to whether the low

phosphorus supply affected in any way the constitution of the milk fat. In order to obtain evidence on this point the butter-fat was examined for five different periods in experiment 3.

1. Fat from the milk of April 19th to 20th. High phosphorus feeding immediately after the change from a low phosphorus ration.

2. Fat from milk of April 29 to 30, ten days after the change from a low phosphorus to a high phosphorus ration.

3. Fat from milk of May 7 to 8. Low phosphorus ration immediately after a change from the high phosphorus ration.

4. Fat from the milk of May 22 to 23, fifteen days after the change from a high phosphorus ration.

5. Fat from milk six weeks after the cow had been placed on the regular ration of the Station herd. This represents butter fat produced under entirely normal conditions.

The results of these examinations are given in the following table:

TABLE XLIV.—COMPOSITION OF BUTTER FATS.

No.	Phosphorus ration.	Volatile acids.	Soluble acids.	Insoluble acids.	Iodine absorp.	Koet. No.	Melting point.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*		
1...	High.......	31.62	5.61	86.89	26.91	239	31.25
2...	High.......	33.82	5.65	85.99	26.47	240	30.70
3...	Low.......	29 60	4.91	87.40	25.41	236	32.44
4...	Low.......	26.29	4.75	87.31	26.23	234	33.15
5...	Normal.....	26.21	5.10	88.59	37.93	232	31.50

The indications are that the constitution of the milk fat was somewhat modified by the change in the rations. The volatile and soluble fatty acids are in smaller proportion in the fat produced by the low phasphorus ration while the melting point is somewhat higher, facts that are entirely consistent with each other, and are an additional indication of a specific influence upon milk-fat secretion of the compounds taken out of the bran by leaching with water.

The source of the phosphorus given up from the body store during the periods of low phosphorus feeding.—Since these two animals were able to sustain a loss of phosphorus compounds from the body store during considerable periods of time without any apparently serious consequences to the general health, it becomes an interesting question as to what part of the body store was drawn

upon. The fact that the nitrogen excretion was not increased during the feeding of the low phosphorus rations would indicate that there was no cleavage of the nucleo-proteid bodies stored in the tissues unless, indeed, it is possible for such cleavage to occur and leave the proteid component of these bodies intact.

It would appear reasonable to expect that the deficiency in the phosphorus compounds of the food would be made good from the body supply of what may be called the circulatory phosphorus compounds, that is, those which are soluble or transferable. Facts are available which enable us to consider this point of view more or less intelligently. Emmett & Grindley[35] in their researches on the chemistry of the flesh of steers, have made a study of its phosphorus content in various forms. Their results show that the total phosphorus from such flesh soluble in cold water ranged from .146 per ct. to .257 per ct., averaging approximately .2 per ct. Of this .12 per ct. consists of soluble inorganic phosphorus bodies, chiefly potassium phosphates, only about .08 per ct. being in the form of organic phosphorus compounds.

In an experiment by Jordan[36] concerning the relation of food to the growth and composition of the bodies of steers, it was found that the soft tissues of the bodies of the experimental animals, exclusive of the blood and the contents of the stomach and intestines, represented about 51 per ct. of the total body weights. Assuming the same relations for the bodies of the animals in these experiments and that the soft tissues contain .2 per ct. of phosphorus in soluble or transferable combinations, we find by computation that the total quantity of such phosphorus would be approximately 525 and 450 grams for cows 1 and 2 respectively. The figures of the preceding tables show that there was one period at least in which the phosphorus deficiency approximated 10 grams daily for 30 days. The question is, then, whether from the store of soluble phosphorus compounds an amount equal to 300 grams of phosphorus could be withdrawn without serious results to the animal's health. That this could happen certainly seems improbable.

Attention has been called to tables 39-41, which shows the income and outgo of the oxides of calcium, magnesium and potassium

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[35] *Jour. Amer. Chem. Soc.*, 28: 25. 1906.
[36] Maine Agr. Expt. Sta., Rpt. 1895, p. 36.

during two periods of four days each, one with an excess and the other with a deficiency, of phosphorus compounds in the ration. The unlike results in the two periods appear to be significant in their relation to the supply of phosphorus compounds. During the period of low phosphorus supply the withdrawal of calcium compounds from the body store was greatly increased, with a somewhat corresponding increase in the storage of potassium oxide. There was a storage of magnesium oxide in both the high and low phosphorus periods, this being considerably greater in the former. These facts would indicate that there was a replacement of calcium oxide by another base, particularly in the period of low phosphorus feeding. On the other hand the greatly increased excretion of calcium compounds in the low phosphorus period suggests a cleavage of calcium compounds in some way connected with the deficiency of phosphorus in the food, the most natural inference being that the egested phosphorus not supplied by the food was obtained from a body compound containing calcium oxide as a base.

The metabolism and excretion of phosphorus and other mineral compounds of the food.—It has been shown that the phosphorus of the catabolized phytin and nucleo-proteids appears in inorganic combinations mostly in the feces, though to some extent in the urine, and that the calcium oxide which is withdrawn from the body store is excreted in a quite similar manner. These are facts of general physiological interest and are confirmatory of the observations made by other investigators.

The question as to where the cleavage of the compounds under consideration takes place is an interesting one. In order to throw light on this problem we have studied the action of trypsin and pepsin on the free acid of phytin and its simple salts without securing evidence of the power of these enzyms to split these bodies into inorganic forms. To be sure, the influence of other enzyms such as erepsin and of bacterial ferments has not been tested and so we have no direct proof that these latter might not effect a cleavage of the phosphorus bodies we are studying, but this hardly seems probable.

It is certain that phytin entirely disappeared from the intestinal tract and did not reappear even in small proportions in the milk or urine. By our methods of analysis it is possible to determine very

small amounts of soluble organic phosphorus but elaborate examinations of large quantities of milk, urine and feces during a time when the animal was receiving an excessive amount of phytin, failed to reveal its presence even in minute proportions. These facts, together with the failure to cause a cleavage of phytin through the action of enzyms, indicate that this body was absorbed, metabolized, and its phosphorus excreted, largely through the feces, in inorganic forms.

The observations of other experimenters show clearly that the presence of any compound in the feces is not proof that it has not been absorbed into the body cavity. Bergman[37] demonstrated that when glycero-phosphoric acid is injected subcutaneously into a sheep the phosphoric acid is excreted in the dung. Mendel & Thacher[38] have also shown that mineral compounds that are absorbed from the intestinal tract may afterward appear in the feces. There is a growing evidence among physiologists that the alimentary canal is a channel for the excretion of something more than the substances which have failed of digestion and absorption, and consequently that the percentage of digestibility of certain compounds is not measured by the difference between the amounts of these compounds in the food and in the feces. It seems to be practically established that the claim made by Rubner[39] that the loss through non-absorption of the mineral constituents of whole wheat flour as compared with patent flour is much greater in the case of the former, does not rest on a sound basis, an observation which applies equally well to all conclusions reached in a similar manner. A comparison of the mineral compounds of the constituents of the food with those in the fecal discharge evidently can not be depended upon as a means of ascertaining the availability and usefulness of the ingested mineral compounds.

The foregoing data include many interesting facts, but do not justify final conclusions concerning the main points under investigation. On the basis already established, however, the authors plan to continue the inquiry with the hope of reaching a more complete solution of the problems involved.

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[37] *Jahresber. Agr. Chem.*, 3d F., 4: 354. 1901.
[38] *Amer. Jour. Physiol.*, 11: 5. 1904.
[39] *Zeit. Biol.*, 19: 45, 1883.

THE "KING SYSTEM" OF STABLE VENTILATION.*

W. H. JORDAN.

This system was devised by Prof. F. H. King, formerly of the Wisconsin Agricultural Experiment Station, and has come into quite general use in recently constructed dairy barns and horse stables and in remodeled older buildings. It is in successful operation in both dairy barn and horse barn at this Station.

The system provides for the removal of foul air from near the floor (openings A, A, Fig. 1), under ordinary conditions or from near the ceiling (openings B, B) when the circulation of air is sluggish or when it is desired to remove warm air quickly. These air exits are closed by register valves, and open into a duct, partly in the side wall of the stable, which is made practically airtight. It is also insulated by double walls and air chamber and, though near the roof for part of its course, is separated from it a considerable distance. By these means too rapid cooling of the rising warm air is avoided, which would cause condensation of moisture, and dampness. The two ducts from the side unite (at D) in a single duct which leads to a point well above the roof where it discharges through a ventilator that cuts off down drafts from outside air currents but allows rapid removal of the outflowing air.

The system also provides for the entrance of fresh air. This is taken in at the bottom of a duct in the wall (F, Fig. 1), and discharged into the room near the ceiling. As shown by the floor plan and side elevation there are two outflow ducts on each side of the stable and three inflow ducts. This secures good distribution of the fresh air.

In the Station stable, 33 x 51 feet and accommodating 22 to 26 cows, the 4 outflow tubes are each 10 x 16 inches, giving 640 square inches, or 29 to 24 square inches to each animal; and the 6 inflow ducts are each 6 x 16 inches, giving 576 square inches, or 26 to 21 square inches to each cow. Prof. King suggests a 2 ft. by 2 ft. ventilating flue for each 20 cows, giving about 29 square inches for each cow.

If the system is to be installed provision should be made to have it *do all the ventilating;* that is, walls, windows, doors and ceiling must be made tight.

* A reprint of Circular No. 7, n. ser.

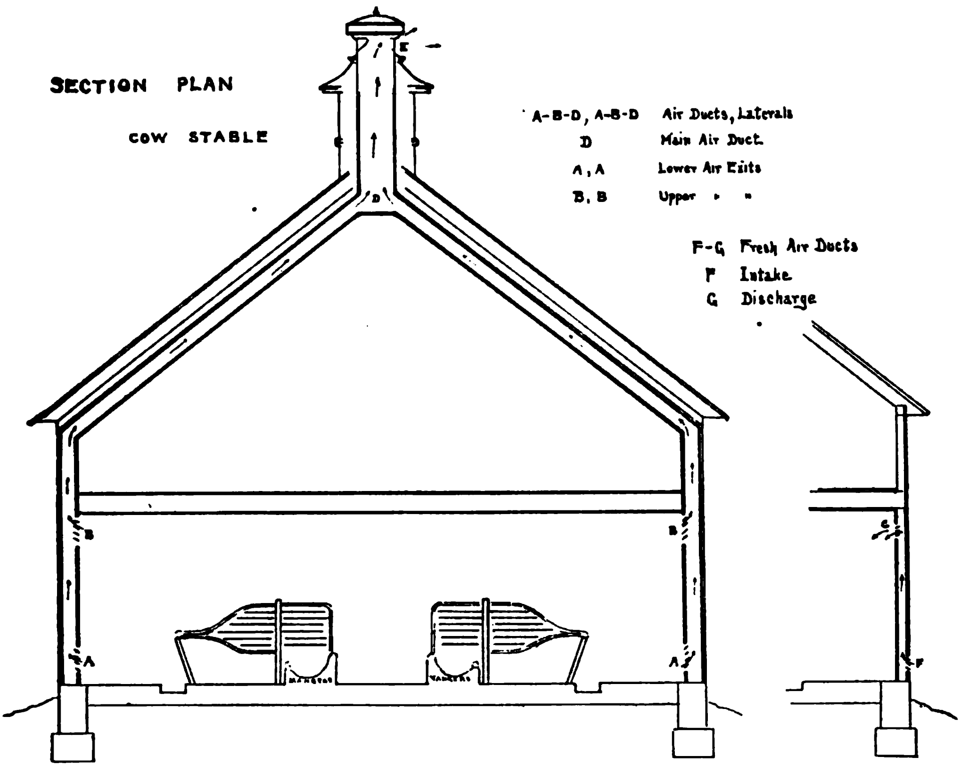

FIG. 1.— SECTION OF CATTLE BARN AT NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y., SHOWING SYSTEM OF VENTILATION.

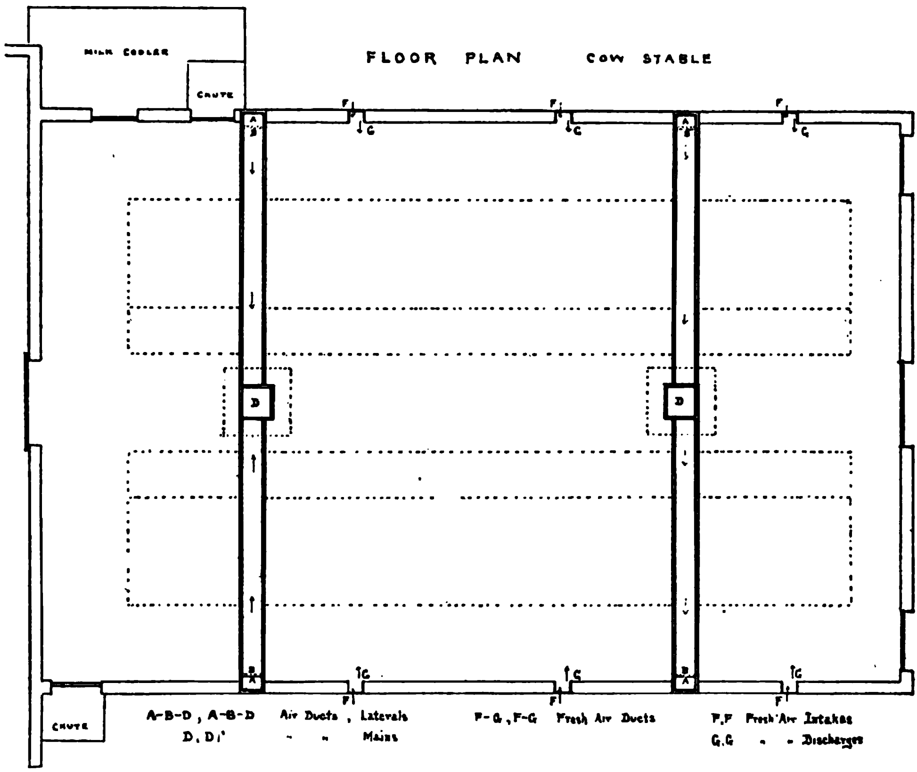

FIG. 2.— PLAN OF COW STABLE AT NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y., SHOWING LOCATION OF AIR DUCTS.

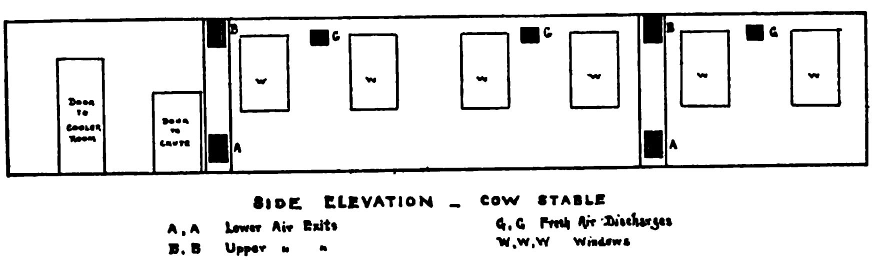

FIG. 3.— ELEVATION OF EAST SIDE OF COW STABLE AT NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y., SHOWING LOCATION OF AIR ENTRANCES AND DISCHARGES.

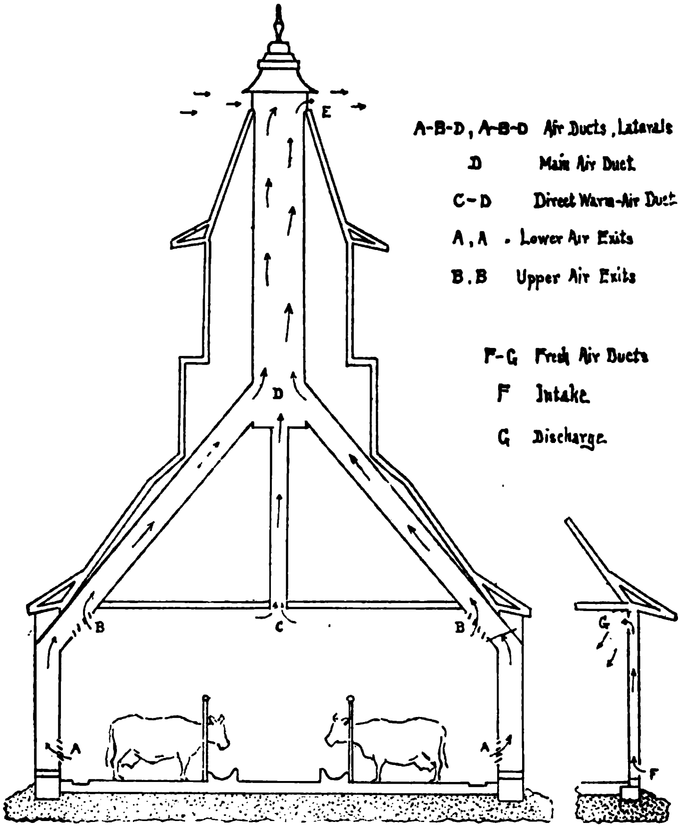

FIG. 4.— SECTION OF CATTLE BARN AT EXPERIMENT STATION, MADISON, WIS., SHOWING SYSTEM OF VENTILATION.

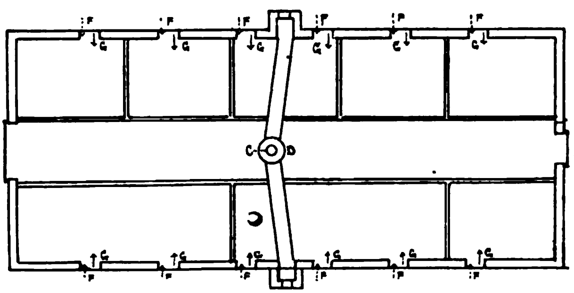

FIG. 5.— PLAN OF COW STABLE AT EXPERIMENT STATION, MADISON, WIS., SHOWING LOCATION OF AIR DUCTS.

REPORT

OF THE

Department of Bacteriology.

H. A. HARDING, *Bacteriologist.*

M. J. PRUCHA, *Assistant Bacteriologist.*

JAMES WILSON, *Assistant Bacteriologist.*

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REPORT OF THE DEPARTMENT OF BACTERIOLOGY.

THE QUALITY OF COMMERCIAL CULTURES FOR LEGUMES IN 1906.*

H. A. HARDING AND M. J. PRUCHA.

SUMMARY.

Cultures of legume bacteria dried upon cotton according to Moore's method have been tested by sixteen Agricultural Experiment Stations in 1904–5 and all have found such cultures to be of little or no practical value.

Metal containers have been recently put forth as a means of protecting such cultures and it was claimed that cultures packed in this way would remain active for long periods.

A careful examination of fourteen such cultures showed that the claims made for the metal container were not borne out in practice.

The results from the examinations of twenty commercial cultures indicate that the goods upon the market for 1906 were little if any better than those offered in 1905.

In neither year was there any evidence that the purchaser had had more than the remotest chance of receiving the worth of his money from the use of such cultures.

INTRODUCTION.

During the years 1904–5 great interest was manifested throughout the country in the artificial inoculation of legumes with their appropriate bacteria in order to stimulate the fixation of nitrogen from the air. This interest was due to the sensational manner in

which this subject was brought to the public notice at a time when farmers were beginning to realize the importance of legumes in soil enrichment and to know what substantial results had been obtained by the use of naturally inoculated soils. That this interest was due to the manner of presentation rather than to the newness of the subject matter is seen from the following facts: Practically identical culture media[1] had been employed in growing these germs for many years, the idea that the activity of the cultures could be increased by controlling their environment has long been held, especially by Hiltner,[2] and the method of shipment on absorbent material has been considerably used with yeast cultures. The main value of this presentation lay in the fact that it succeeded in bringing these scientific facts to the attention of the agricultural public.

Coincident with this public interest in the subject of artificial inoculation there appeared commercial companies which offered cultures for this purpose. Inquiries concerning the value of these commercial cultures began to pour in at the various Agricultural Experiment Stations and in order to obtain data upon which to answer these inquiries the Experiment Stations made tests of these cultures.

INVESTIGATIONS.

RESULTS FROM PREVIOUS EXAMINATIONS.

The tests by the various Agricultural Experiment Stations were made under a wide range of conditions and in practically all possible ways. They included extensive examinations in the laboratory as well as trials by pot experiments and field tests.

In the tests by sixteen Stations[3], the results from which are now available, there was a striking similarity in one particular; they

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[1] The cultivation of legume bacteria in nitrogen-free media has long been a common practice. Laurent (Recherches sur les nodisites radicales des Legumineuses. *Ann. Inst. Pasteur,* 5: 105. 1891) used the following medium: Distilled water 1000 c.c., potassium phosphate 1 gram, magnesium sulphate, 1 gram, and saccharose.

[2] *Cent. Bakt.* [etc.], II, 10: 660. 1902.

[3] Okla. Agr. Exp. Station Bul. 68. 1905.
New York Agr. Exp. Station Bull. 270. 1905.
W. Va. Agr. Exp. Station Bul. 105. 1906.
Ga. Agr. Exp. Station Bul. 71. 1905.

unite in saying that they have failed to find evidence that these cultures are of any value to the agriculture of their particular regions.

Bulletin 270 of this Station gives the results of bacteriological examinations in 1905 of eighteen packages of inoculated cotton cultures for legumes, put up by the National Nitro-culture Co., of West Chester, Pa. Duplicate portions from six of these packages were examined at the Agricultural Experiment Stations in Delaware, Michigan, New York and New Jersey and by Parke Davis & Co., at Detroit, Mich. These eighteen packages were all found to be worthless for practical purposes. It was further shown experimentally that the failure of these commercial cultures was inherent in the manner of their preparation.

Great stress is laid by the commercial companies upon the results obtained by farmers from the use of these cultures. Of the large number of farmers (approximately a hundred) whose experience has come to us during the past two seasons, but six have believed that they had obtained any result whatever from the use of such cultures. One had tried the inoculation on garden peas. When the matter was reported in November the crop had disappeared, but the statements of both the man and his neighbors left little room for doubt that good results had been obtained. A second farmer had tested inoculation on cow peas, and while he maintained that there was a marked increase in the nodule formation on the inoculated area, there was no discoverable difference in the crop obtained from the two portions. A third was enthusiastic concerning results obtained with alfalfa, but as no plat had been sown without inoculation it was hard to see upon what he based his conclusions. Two other fields of alfalfa where the owners believed

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Me. Agr. Exp. Station Bul. 128. 1906.
Cornell Univ. Agr. Exp. Station Bul. 237. 1906.
Ky. Agr. Exp. Station Bul. 125. 1906.
Ontario Agr. Coll. Bull. 148. 1906.
Pa. Agr. Exp. Station Bull. 78. 1906.
Ann. Rept. Wis. Exp. Station 22: 242. 1905.
Ann. Rept. Mass. Exp. Station 18: 77. 1906.

Unpublished results were kindly furnished by Agricultural Experiment Stations of North Carolina and Virginia.

Also see Report on field and pot culture experiments at Woburn (Eng.) Experiment Station. 1904.

that they had obtained good results from the use of commercial cultures were examined without finding anything upon which to base such conclusions. Another alfalfa field has been reported but has not yet been examined. It would thus appear that the negative results obtained from these cultures in the laboratory at the Experiment Station are in close accord with what is being actually obtained in practice upon the farms.

EFFECT OF THESE RESULTS UPON TRADE CONDITIONS.

It is encouraging to note that while the trade in these commercial cultures was brisk during the season of 1905 the adverse reports which began to appear at the end of that season from the Experiment Stations, the agricultural press and from the farmers themselves, have very markedly reduced the use of these cultures.

MODIFICATION OF THE ORIGINAL METHOD.

Kellerman & Beckwith[4] have shown that when cultures of legume bacteria are placed on cotton, dried promptly and kept absolutely dry, they retain their vitality for a considerable time. The National Nitro-culture Co. took advantage of this fact and put upon the market cultures on cotton inclosed in metal containers. The company claimed thereby to obviate all the objections which had been raised against their cultures as put out during 1905. These metal containers were collapsible tubes similar to those in which bicycle cement is commonly sold, except that they had no small opening and were closed by rolling up and compressing the large end. That such a closure does not completely cut off the air is plain to anyone who has purchased a tube of bicycle cement which has been long in stock.

Since it was this company whose preparations had been found worthless last year, common justice demanded that their product be again tested and if found to be as much improved as claimed by them the fact should be given as wide circulation as had the condemnation of their product of the preceding season.

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[4] Kellerman, K. F., & Beckwith, T. D. Effect of drying upon legume bacteria. *Science*, N. S., 23:471–472. 1906.

EXAMINATION OF CULTURES IN 1906.

Duplicate acre packages for three legumes were purchased from each of three seedsmen, or eighteen packages in all. Mr. C. K. Scoon, a local farmer, very kindly made the purchase for us.

The cultures had all been put up by the National Nitro-culture Co., and since they bore the date 1906 were surely not old cultures which had been long in the hands of the seedsmen. Twelve packages, six for alfalfa and six for crimson clover, were contained in the metal tubes, while the six cultures for vetch were wrapped in parchment paper and tin foil, as was the case with the packages last season. This could hardly have been an accident since it was equally true of the cultures received from each of the three seedsmen.

Method of making the examinations.—The chemicals used in all cases were those accompanying the cultures. They were dissolved in the appropriate amount of rain water and the solutions sterilized in order to reduce the chance of outside contaminations and enable us to determine just what germs were on the cotton. In making a test of these commercial cultures the packages were carefully opened and the inoculated cotton divided into three equal portions with sterile instruments and under conditions which exposed the material to the least possible opportunity for contamination. In each case one of these portions was placed in a flask containing 100 c. c. of the sterile nutrient solution above described. The remainder of the cotton was returned to the original container and sealed as before.

The flasks were held at 25° C. (77° F.). At the end of twenty-four hours the proper amount of sterile ammonium phosphate was added. The formation of turbidity was noted and the contents examined by means of hanging drop and stained cover glass preparations. Peptone-free agar plates were inoculated from each flask at the end of two, and again at the end of five days. Any colonies resembling the legume bacteria which appeared upon the plates were given further study.

In the case of each examination of these cultures two series of control flasks were also used. One series received the same treatment as the test flask with the exception that in place of the cotton these flasks received a portion of a pure culture of legume bacteria. In the other series the flasks received the same chemicals and exposure to contamination but did not receive either cotton or in-

tentional inoculation. The object of the first series was to show that the conditions in the flasks were such that the legume bacteria could make successful growth, while the second series was intended to measure the probability of the flasks becoming accidentally contaminated during the process of manipulation. The flasks inoculated with legume bacteria uniformly produced both an abundant and a pure growth of the germ with which they had been seeded. This shows that the conditions were good for the development of any legume bacteria which might be present upon the cotton. The uninoculated flasks remained sterile, indicating that there was slight probability that any of the flasks became accidentally contaminated during the process of the test.

Results of the examinations.—A test of each of the eighteen cultures was begun on November 10 and a second test, using a second portion from each commercial package, was started November 15, 1906. While each of these tests was carried through entirely separate the data are here combined into a single table, in order that the results may be more easily compared.

TABLE I.—RESULTS OF THE EXAMINATION OF NITRO-CULTURES.

No. of package.	Legume.	Series No.	Became turbid.	Remarks.
I	Alfalfa	1	Not in 7 days.	Sterile.
		2	Not in 7 days.	Sterile.
II	Alfalfa	1	3 days	Bacterial contamination, 30 per ct. *Ps. radicicola.*
		2	6 days	Bacterial contamination, 20 per ct. *Ps. radicicola.*
III	Alfalfa	1	Not in 7 days.	Sterile.
		2	5 days	Yeast.
IV	Alfalfa	1	Not in 7 days.	Sterile.
		2	7 days	Yeast and molds.
V	Alfalfa	1	7 days	Yeast and molds.
		2	7 days	Molds and pink yeast.
VI	Alfalfa	1	Not in 7 days.	Sterile.
		2	7 days	Yeast and foreign bacteria.
VII	Crimson clover	1	4 days	Yeast.
		2	3 days	Yeast and molds.
VIII	Crimson clover	1	7 days	Yeast.
		2	4 days	Yeast.
IX	Crimson clover	1	7 days	Pink yeast.
		2	5 days	Pink yeast.
X	Crimson clover	1	3 days	Foreign bacteria.
		2	6 days	Foreign bacteria and molds.
XI	Crimson clover	1	7 days	Pink yeast and foreign bacteria.
		2	4 days	Yeast and molds.
XII	Crimson clover	1	7 days	Molds.
		2	5 days	Molds.
XIII	Vetch	1	5 days	Foreign bacteria and 5 per ct. *Ps. radicicola.*
		2	4 days	Foreign bacteria.
XIV	Vetch	1	2 days	40 per ct. *Ps. radicicola*, foreign bacteria.
		2	4 days	50 per ct. *Ps. radicicola*, foreign bacteria.
XV	Vetch	1	2 days	Foreign bacteria.
		2	2 days	Foreign bacteria.
XVI	Vetch	1	4 days	Yeast and molds, 5 per ct. *Ps. radicicola.*
		2	7 days	Molds and yeast.
XVII	Vetch	1	6 days	Molds and foreign bacteria.
		2	4 days	Molds and yeast.
XVIII	Vetch	1	5 days	Molds.
		2	2 days	Foreign bacteria, molds and yeast.

It will be seen that no legume bacteria could be found in fourteen of the eighteen cultures examined. In two of the four commercial cultures where legume bacteria were found they were present in very small numbers, and had they been exposed to the mixed growth which occurs when the cultures are developed upon the farm, it is very doubtful whether any result would have been obtained from the use of these cultures. In the two commercial cultures where the legume bacteria developed sufficiently to represent from 20 per cent. to 50 per cent. of the germs present, they would probably have developed in some numbers under ordinary conditions. That such cultures do occasionally develop in this way seems probable from the few apparently well authenticated cases where good results have followed the use of commercial cultures.

The finding of even this small number of the desired bacteria marks a decided advance over the conditions found last season, but at best makes only a very poor showing for the cultures.

Yeast and molds invariably developed in the flasks. In some cases the turbidity appearing in three or four days was due to these organisms. The bacterial contaminations consisted of several different organisms.

Packages Nos. 1 to 12 were in metal containers while packages Nos. 13 to 18 were wrapped in parchment paper and tin foil. Our data fail to show that the metal containers exerted any favorable influence upon the legume bacteria. The only apparent difference between the cultures inclosed in the metal containers and those wrapped in parchment paper and tin foil was that the latter were more heavily contaminated.

CULTURES FROM OTHER SOURCES.

During the season we examined two other packages of inoculated cotton cultures put up by this same firm and inclosed in metal containers.

In May, 1906, Prof. J. L. Stone developed a culture on cotton for alfalfa, following the directions carefully. The solutions became turbid at the proper time and everything seemed normal. The seed was inoculated on the second day, and plates inoculated with the fluids at that time showed only an occasional colony of the legume bacteria. There was an abundant growth of miscellaneous forms. Professor Stone reports that the culture was without discoverable effect upon the alfalfa.

In August, 1906, a package of Nitro-culture in metal container was sent in by Mr. W. A. Runyon, Westtown, Orange county, with a request that its quality be determined. A portion of the cotton cultures was placed in the proper sterile solutions and allowed to develop. Examinations with the microscope and by means of plates failed to detect the presence of the desired legume bacteria.

CONCLUSIONS.

It would seem from these results that the strong claims made by the culture company for the metal containers are not at all in accord with the facts.

It should be clearly understood that this publication concerns itself only with the commercial cultures which up to this time have been exclusively those dried upon cotton in accord with the method of Dr. Moore. These cultures have proved essentially a complete failure in tests made in practically all parts of the country and it is hard to understand how any firm can feel justified in continuing to offer such cultures for sale.

REPORT

OF THE

Botanical Department.

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H. J. EUSTACE, *Assistant Botanist.*

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F. A. SIRRINE, *Special Agent.*

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REPORT OF THE BOTANICAL DEPARTMENT.

POTATO-SPRAYING EXPERIMENTS IN 1905.*

F. C. STEWART, H. J. EUSTACE AND F. A. SIRRINE.

SUMMARY.

The fourth year of the ten-year series of potato-spraying experiments begun in 1902 is now completed. During 1905 the work was carried out along the same lines as in 1904. Seventy separate experiments are reported in this bulletin.

TEN-YEAR EXPERIMENTS.

At Geneva, five sprayings increased the yield 119⅓ bushels per acre, while three sprayings increased it 107 bushels. The gain was due partly to prevention of late blight and partly to prevention of rot. At Riverhead, the gain due to five sprayings was 82 bushels per acre and to three sprayings, 31⅓ bushels. Here, the flea beetle was the chief enemy.

FARMERS' BUSINESS EXPERIMENTS.

In thirteen experiments, including 166⅔ acres, the average gain due to spraying was 46½ bushels per acre; the average total cost of spraying, $4.25 per acre; the average cost of each spraying, 98 cents per acre; and the average net profit, $20.04 per acre.

VOLUNTEER EXPERIMENTS.

In fifty experiments, including 407 acres, the average gain due to spraying was 59½ bushels per acre. In 29 of these experiments the average total cost of spraying was $4.57 per acre; the average

*A reprint of Bulletin No. 279.

cost for each spraying, 92 cents; and the average net profit, $29.85 per acre.

SODA BORDEAUX VS. LIME BORDEAUX.

In comparative tests of efficiency of these fungicides, rows sprayed four times with lime bordeaux outyielded rows similarly sprayed with soda bordeaux by 9 bushels per acre in one test and by 35 bushels per acre in another test. For use on potatoes, soda bordeaux is not superior to lime bordeaux.

BORDEAUX WITH AND WITHOUT PARIS GREEN.

Potatoes are in no way injured by paris green properly applied; viz., in moderate amount (one to two pounds per acre) with bordeaux mixture.

BORDEAUX WITH AND WITHOUT ARSENITE OF SODA.

Arsenite of soda may be safely used with bordeaux at the rate of one quart of the stock solution (Kedzie formula) to fifty gallons.

COLD VS WARM BORDEAUX.

Potato foliage was in no way injured by spraying on hot, sunny days with bordeaux having a temperature of 40 degrees to 54 degrees Fahr. It appears that no attention need be paid to the temperature of the water used in making bordeaux for spraying potatoes.

POTATO TROUBLES IN 1905.

In unsprayed fields the loss from blights, rot and flea beetles was at least fifty bushels per acre on the average. Most of this loss was due to late blight and the rot which follows it.

DOES SPRAYING PREVENT ROT?

The general tendency of spraying is to reduce the amount of rot. In most cases the reduction is very marked; in some cases there is no difference; and occasionally spraying increases the amount of rot. It depends on weather conditions and the thoroughness of spraying. But whatever the effect on rot, *sprayed plants always give a larger yield of marketable tubers.*

SPRAYING IS PROFITABLE.

Judging from the experiments thus far made it appears that spraying for blight is an operation which no potato grower in New York can afford to neglect. Thirty-three farmers' business experiments made during the past three years show an average net profit of $22.79 per acre due to spraying.

DIRECTIONS FOR SPRAYING.

Commence spraying with bordeaux when the plants are 6 to 8 inches high and repeat at intervals of 10 to 14 days throughout the season, making, in all, five or six applications. When bugs are troublesome add paris green or other poison.

INTRODUCTION.

During the season of 1905 the Station continued the ten-year potato-spraying experiments begun in 1902. These experiments are designed to determine how much the yield of potatoes can be increased, on the average, by spraying with bordeaux mixture. The plan is to continue the experiments during ten consecutive seasons and take the average increase in yield as the index of the value of spraying potatoes in New York State. The experiments are to be conducted in two localities; namely, at Geneva and Riverhead. Two methods of spraying are to be compared as to their efficiency: Some rows are sprayed every two weeks regularly while others are sprayed only three times during the season. At each place the area of the experiment field is to be three-tenths of an acre each season. The rows sprayed every two weeks alternate with those sprayed only three times and with others not sprayed at all. For further details see Bulletins 221, 241 and 264.

Supplementary to the above experiments, the Station has conducted a series of business experiments similar to those made in 1903 and 1904.[1] Under the direction of the Station, fourteen farmers in different parts of the State have carried on experiments designed to determine the net profit in spraying potatoes in different ways under actual farm conditions.

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[1] For a detailed account of the business experiments in 1903 see Bulletin 241, pages 267–283; in 1904, Bulletin 264, pages 116–152.

A third line of effort has been the collection of the results of numerous volunteer potato-spraying experiments made by farmers. Fifty such experiments are reported in this bulletin. The most important feature of these experiments, as a whole, is the increase in yield due to spraying. However, several of them contain other points of special interest.

SUMMARY OF RESULTS OBTAINED IN TEN-YEAR EXPERIMENTS PRIOR TO 1905:

TABLE I.—YIELD BY SERIES AT GENEVA IN 1902.[2]

SERIES.	Rows.	Dates of spraying.	Yield per acre	
			Bu.	*Lbs.*
I	1, 4, 7 and 13	July 10, 23 and Aug. 12	317	41
II	2, 5, 8 and 14	June 25, July 10, 23, 30, Aug. 12, 26 and Sept. 10	342	36
III	3, 6, 9 and 15	Not sprayed	219	4

Gain due to spraying three times, 98⅔ bu. per acre.
Gain due to spraying seven times, 123½ bu. per acre.

TABLE II.—YIELD BY SERIES AT RIVERHEAD IN 1902.

SERIES.	Rows.	Dates of spraying.	Yield per acre	
			Bu.	*Lbs.*
I	2, 5, 8 and 11	May 26, June 20 and July 12	295	20
II	1, 4, 7 and 10	May 26, June 3, 20, 30, July 11, 23 and Aug. 5	312	35
III	3, 6, 9 and 12	Not sprayed	267	40

Gain due to spraying three times, 27⅔ bu. per acre.
Gain due to spraying seven times, 45 bu. per acre.

TABLE III.—YIELD BY SERIES AT GENEVA IN 1903.[3]

SERIES.	Rows.	Dates of spraying.[4]	Yield per acre	
			Bu.	*Lbs.*
I	1, 4, 7, 10 and 13	July 14, 28 and Aug. 26	262	—
II	2, 5, 8, 11 and 14	July 7, 21, Aug. 7, 21 and Sept. 3	292	10
III	3, 6, 9, 12 and 15	Not sprayed	174	20

[4] The dates of spraying in Table IV on page 263 of Bulletin 241 are incorrect.
Gain due to spraying three times, 88 bu. per acre.
Gain due to spraying five times, 118 bu. per acre.

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[2] For details of the ten-year experiments in 1902 see Bulletin 221.
[3] For details of the ten-year experiments in 1903 see Bulletin 241.

TABLE IV.—YIELD BY SERIES AT RIVERHEAD IN 1903.

SERIES.	Rows.	Dates of spraying.	Yield per acre	
			Bu.	*Lbs.*
I..........	1, 4, 7 and 10.......	June 5, July 22 and Aug. 7...........	246	45
II.........	2, 5, 8 and 11.......	June 5, 24, July 7, 22 and Aug. 7......	263	10
III........	3, 6, 9 and 12.......	Not sprayed.......................	207	10

Gain due to spraying three times, 39⅓ bu. per acre.
Gain due to spraying five times, 56 bu. per acre.

TABLE V.—YIELD BY SERIES AT GENEVA IN 1904.[5]

SERIES.	Rows.	Dates of spraying.	Yield per acre	
			Bu.	*Lbs.*
I..........	1, 4, 7, 10 and 13....	July 13, 27 and Aug. 15..............	344	30
II.........	2, 5, 8, 11 and 14....	July 8, 22, Aug. 1, 15 and 29..........	386	40
III........	3, 6, 9, 12 and 15....	Not sprayed.......................	153	25

Gain due to spraying three times, 191 bu. per acre.
Gain due to spraying five times, 233 bu. per acre.

TABLE VI.—YIELD BY SERIES AT RIVERHEAD IN 1904.

SERIES.	Rows.	Dates of spraying.	Yield per acre	
			Bu.	*Lbs.*
I..........	1, 4, 7 and 10........	June 14, July 21 and Aug. 9..........	257	58
II.........	2, 5, 8 and 11.......	June 14, 27, July 11, 26, Aug. 9 and 22.	297	45
III........	3, 6, 9 and 12.......	Not sprayed.......................	201	25

Gain due to spraying three times, 56⅓ bu. per acre.
Gain due to spraying six times, 96⅓ bu. per acre.

DETAILS OF THE TEN-YEAR EXPERIMENTS IN 1905.

SOIL, PLANTING, CULTIVATION, ETC.

At Geneva.—The plat of land used was the same as that used for this experiment in 1903. It was a heavy clay loam containing some gravel. The surface drainage was good. During the season of 1904 it was seeded with red clover. The seed potatoes were of the variety Rural New Yorker No. 2 selected from sprayed rows in the experiment of 1904. They were planted May 16 in rows three feet apart and with the hills 15 inches apart in the row. The cultivation was barely sufficient to keep down weeds. No doubt, considerably larger yields would have been obtained if the plants had received the proper amount of cultivation.

At Riverhead.—The land used at Riverhead was a level plat of sandy loam on the farm of Mr. G. F. Downs. The soil was of better quality and less sandy than that used for the experiment in

[5] For details of the ten-year experiments in 1904 see Bulletin 264.

former years and more nearly representative of the soil of eastern Long Island. In 1904 the land grew cauliflower. The seed potatoes were of the variety Green Mountain planted by hand, April 25 and 26, in rows three feet apart with the hills 15 inches apart in the row. The plants were given good cultivation throughout the season.

PREPARATION AND APPLICATION OF THE BORDEAUX MIXTURE.

Both at Geneva and at Riverhead the bordeaux mixture used was approximately of the 1-to-8 formula and applied very thoroughly with a knapsack sprayer as in former years.

DATES OF SPRAYING.

At Geneva: Series I.—The rows of this series, 1, 4, 7, 10 and 13, were sprayed three times with bordeaux mixture — July 3, August 7 and 25. At the time of the first spraying the plants averaged about one foot in height. Some hills were badly infested with bugs, but the majority of the plants were yet uninjured. Paris green was applied with the bordeaux at the rate of one-half pound to fifty gallons. This application was so effective in ridding the plants of bugs that it was unnecessary to use poison again. Consequently, the second and third sprayings were made with bordeaux alone at such times as seemed best for the control of blight.

Series II.—This series consisted of rows 2, 5, 8, 11 and 14. The plants were sprayed with bordeaux mixture five times — June 29, July 13 and 27, and August 12 and 24. At the time of the first spraying the plants were 7 to 10 inches high. The bugs were just commencing to hatch, so paris green was used with the bordeaux at the rate of one-half pound to fifty gallons. On July 13 when the second spraying was made it was necessary to use poison a second time. There were then more bugs on this series than on either series I or III. Evidently, the first application of poison was made a little too early for the best results on bugs. No poison was used in the last three sprayings.

Series III.—Series III consisted of rows 3, 6, 9, 12 and 15. It was the intention not to use any bordeaux on these rows, but row 3 was accidentally sprayed once with bordeaux on August 24. The

plants on this series were kept free from bugs by three applications of paris green in lime water (one-half pound to fifty gallons) made July 3, 13 and August 12.

At Riverhead: Series I.—This series consisted of five rows—Nos. 1, 4, 7, 10 and 13, which were sprayed with bordeaux mixture three times; namely, on June 14, July 18 and August 11. Paris green, at the rate of one pound per acre, was applied three times. The first application was made with bordeaux mixture in the first spraying of June 14 and the other two in lime water on June 30 and July 14.

Series II.—This series consisted of five rows—Nos. 2, 5, 8, 11 and 14. They were sprayed with bordeaux mixture five times; namely, on June 14, 30, July 14, 28 and August 11. Paris green was used only in the first two sprayings at the rate of one pound per acre.

Series III.—Series III consisted of five rows—Nos. 3, 6, 9, 12 and 15. These rows received no bordeaux. Paris green in lime water was applied three times (June 14, 30 and July 14) at the rate of one pound per acre.

RESULTS OF THE TEN-YEAR EXPERIMENTS IN 1905.

AS SHOWN BY THE CONDITION OF THE FOLIAGE.

At Geneva.—When the plants were 3 to 6 inches high they were slightly injured by flea beetles before spraying was commenced. Later, about August 1, the beetles again appeared in larger numbers and during the next month injured the unsprayed rows of Series III considerably. The plants of Series II, on the contrary, were scarcely affected, showing very plainly the beneficial influence of bordeaux in controlling the flea beetle. On Series I, where the spraying was less thorough, they caused some damage.

Early in August tip-burn began to appear on the unsprayed rows and continued to increase until it became quite prominent. Strange to say, the sprayed rows were almost entirely free from it. Tip-burn is a physiological disorder and it is difficult to explain why spraying should prevent it. Possibly the unsprayed rows suffered more because they had been more injured by flea beetles.

Early blight, *Alternaria solani,* was almost entirely absent.

Late blight, *Phytophthora infestans,* was first found on the unsprayed rows August 12. It spread slowly. In fact we regarded this as a rather mild attack. However, as a result of the combined attack of flea beetles, tip-burn and late blight the unsprayed rows (excepting row 3) died fully two weeks earlier than the sprayed rows of Series I and II. Row 3, having been sprayed once by mistake, remained green a few days longer. The contrast in appearance between the sprayed and unsprayed rows was very marked but not as striking as in 1904. It was probably greatest about September 21, at the time the photograph shown in Plate I was taken. Between Series I, sprayed only three times, and Series II, sprayed five times, there was no apparent difference in foliage. On September 26 each series still retained somewhat less than one-half of its foliage. By October 3 practically all of the plants were dead.

At Riverhead.—In the experiment at Riverhead late blight did no damage whatever, not even to the unsprayed rows. Flea beetles and early blight were the chief enemies fought. According to their usual habit, flea beetles appeared while the plants were small, about June 10, and again, in hordes, when the plants were full grown about the middle of July. On July 29 there was a marked difference between the foliage on Series II and that on Series I and III. Series I and III were severely injured by flea beetles, but thorough spraying had prevented most of the injury on Series II. Here again, the value of bordeaux mixture as a remedy for the flea beetle was clearly shown.

Early blight appeared about August 1. It did some damage to Series II, but considerably more to Series I and III. Unlike the experiment at Geneva, we had here much better foliage on Series II, sprayed five times, than on Series I, sprayed three times.

AS SHOWN BY THE YIELD.

At Geneva.—The potatoes were dug by hand October 21. At this time the unsprayed plants had been dead over a month and the sprayed plants about 18 days.

The product of each row was carefully sorted into three grades —marketable, rotten and culls. According to our usual method, all sound tubers larger than a hen's egg were graded as marketable.

TABLE VII.—YIELDS IN THE EXPERIMENT AT GENEVA.

Section.	Row.	Treatment.	Yield per row.[6] Marketable.	Yield per row.[6] Culls.	Yield per acre. Marketable.		Yield per acre. Culls.	
			Lbs.	*Lbs.*	*Bu.*	*Lbs.*	*Bu.*	*Lbs.*
	1	Sprayed 3 times.........	280	39	233	20	32	30
A.......	2	Sprayed 5 times.........	269	42	224	10	35	—
	3	Unsprayed[7]............	191	47	159	10	39	10
	4	Sprayed 3 times.........	258	38	215	—	31	40
B.......	5	Sprayed 5 times.........	295	40	245	50	33	20
	6	Unsprayed.............	130	28	108	20	23	20
	7	Sprayed 3 times.........	284	38	236	40	31	40
C.......	8	Sprayed 5 times.........	270	39	225	—	32	30
	9	Unsprayed.............	154	34	128	20	28	20
	10	Sprayed 3 times.........	271	38	225	50	31	40
D.......	11	Sprayed 5 times.........	292	45	243	20	37	30
	12	Unsprayed.............	153	42	127	30	35	—
	13	Sprayed 3 times.........	285	48	237	30	46	40
E.......	14	Sprayed 5 times.........	302	46	251	40	38	20
	15	Unsprayed.............	148	42	123	20	35	—

[6] Rows 290.4 feet long by three feet wide making the area of each row exactly one-fiftieth acre. Concerning the loss from rot see page 128.
[7] It will be observed that Row 3 gave the largest yield of any unsprayed row. This is owing to it having been sprayed once by mistake. Hence, in computing the average yields all three rows of Section A should be rejected.

Comments on the table.—(1) In Sections A and C the three-sprayed row outyielded the five-sprayed row. The reason for this is unknown but it is certainly not due to the spraying.

(2) In every section both of the sprayed rows greatly outyielded the unsprayed row.

(3) In different sections the yields of rows treated in the same way varied considerably. This has happened also in all three of the previous experiments. It can not be avoided. Confidence is to be placed only in averages.

(4) Leaving Section A out of consideration (because of the error on Row 3) there were fewer culls on the unsprayed than on the sprayed rows. On the unsprayed rows the average yield of culls was 30 bu. 25 lbs. per acre while on both of the sprayed series the average was 35 bu. 25 lbs. per acre. This is somewhat unusual. As a rule there are more culls on the unsprayed rows. In the ten-year experiment at Geneva in 1904 there were more than twice as many culls on the unsprayed rows as on the sprayed.

Yield by series.—The four rows sprayed three times constitute Series I and the average yield of these four rows makes the yield of Series I. The yields given for Series II and III have been com-

puted in the same manner. The yield by series is shown in the following table:

TABLE VIII.—YIELD BY SERIES AT GENEVA.

SERIES.	Rows.[8]	Dates of spraying.	Yield per acre	
			Bu.	*Lbs.*
I.........	4, 7, 10 and 13......	July 3, August 7 and 25...............	228	45
II.........	5, 8, 11 and 14......	June 29, July 13, 27, August 12 and 24.	241	15
III........	6, 9, 12 and 15......	Not sprayed........................	121	52

[8] The rows of Section A (Nos. 1, 2 and 3) have been omitted because of error.
Increase in yield due to spraying three times, 107 *bu. per acre.*
Increase in yield due to spraying five times, 119½ *bu. per acre.*

This year the difference in yield between Series I, sprayed three times, and Series II, sprayed five times, was less than ever before, being only 12½ bushels per acre. Considering that there was no apparent difference in the foliage no marked difference in yield was to be expected.

Loss from rot.—The loss from rot was greater than in any of the preceding experiments. Owing to the fact that some of the affected tubers were in an advanced stage of decay it was impossible to determine accurately the loss from rot, but on each row the approximate weight of rotten tubers was ascertained. It was found that on Series I, sprayed three times, the loss from rot was at the rate of 6 bu. 40 lbs. per acre; on Series II, sprayed five times, 6 bu. 15 lbs. per acre; while on Series III, not sprayed, it was 47 bu. 30 lbs. per acre. In other words *spraying reduced the loss from rot by* 41 *bushels per acre.* Such was the situation at digging time. It sometimes happens that potatoes apparently sound at digging time subsequently decay in storage. This happened in the ten-year experiment at Geneva in 1904. (See foot note on page 112 of Bulletin 264). In order to determine the extent of such loss in the 1905 experiment the tubers from each of three rows (Rows 8, 9 and 10) were stored in crates in a good cellar from October 21 until December 9 and then examined. In the four and one-half bushels of tubers from Row 8 there were only two affected tubers; in two and one-half bushels from Row 9 there were also two affected tubers while in the four and one-half bushels from Row 10 not a single tuber showed signs of rot. The potatoes were not sorted more carefully at digging time in 1905 than in 1904. Our opinion is that in 1904 the potatoes were dug too soon after the tops died.

Plate I.— Rows 8, 9 and 10 in Ten-Year Experiment at Geneva.

FIG. I.— MARKETABLE TUBERS.

FIG. 2.— ROTTEN TUBERS.
Spraying reduced the loss from rot by 4 bu. per acre.

PLATE II.—PRODUCT IN TEN-YEAR EXPERIMENT AT GENEVA.

At Riverhead.—In the experiment at Riverhead the potatoes were dug on September 16 and sorted into two grades, marketable tubers and culls, in the same manner as at Geneva.

TABLE IX.—YIELDS IN THE EXPERIMENT AT RIVERHEAD.

SECTION.	Row.	Treatment.	YIELD PER ROW.*		YIELD PER ACRE.			
			Marketable.	Culls.	Marketable.		Culls.	
			Lbs.	*Lbs.*	*Bu.*	*Lbs.*	*Bu.*	*Lbs.*
A.......	1	Sprayed 3 times.........	295	22	270	25	20	1
	2	Sprayed 5 times.........	327	20	299	45	18	20
	3	Not sprayed............	244	26	223	40	23	50
B.......	4	Sprayed 3 times.........	272	23	249	20	20	45
	5	Sprayed 5 times.........	335	23	307	5	20	45
	6	Not sprayed............	255	20	233	45	18	20
C.......	7	Sprayed 3 times.........	285	16½	261	15	15	7
	8	Sprayed 5 times.........	335	15	307	5	13	45
	9	Not sprayed............	248	18	227	20	16	30
D.......	10	Sprayed 3 times.........	271	17	248	25	15	35
	11	Sprayed 5 times.........	314	25	287	50	22	55
	12	Not sprayed............	205	18	187	55	16	30
E.......	13	Sprayed 3 times.........	257	20	235	35	18	20
	14	Sprayed 5 times.........	345½	15½	316	42	14	12
	15	Not sprayed............	256	23½	234	40	21	32

* Originally, the rows were 290.4 feet long. Owing to the influence of nearby trees plants near the west end did not thrive and so it was believed that the test would be a fairer one if this portion of the field was left out of consideration in making up the yields. The yields given are for rows 264 feet long by three feet wide, 55 rows being required to make an acre.

Comments on the table.—As in previous years, the gain from spraying in this experiment was smaller than in the experiment at Geneva. On the average, five sprayings gave markedly better results than three sprayings. In each section both of the sprayed rows outyielded the unsprayed row and the row sprayed five times outyielded the row sprayed three times.

TABLE X.—YIELD BY SERIES AT RIVERHEAD.

SERIES.	Rows.	Dates of spraying.	Yield per acre	
			Bu.	*Lbs.*
I.........	1, 4, 7, 10 and 13....	June 14, July 18 and Aug. 11.........	253	—
II.........	2, 5, 8, 11 and 14....	June 14, 30, July 14, 28 and Aug. 11...	303	41
III........	3, 6, 9, 12 and 15....	Not sprayed.........................	221	38

Increase in yield due to spraying three times, 31½ bu. per acre.
Increase in yield due to spraying five times, 82 bu. per acre.

Loss from rot.—There was no trace of rot in this experiment, not even on the unsprayed rows.

FARMERS' BUSINESS EXPERIMENTS.

OBJECT OF THE EXPERIMENTS.

Many farmers question the reliability of the results obtained in experiments like the Station ten-year experiments described in this bulletin. They doubt that such results can be obtained in ordinary farm practice. The common objections to the experiments are: (1) They are on too small a scale (three-tenths of an acre); (2) the spraying is done more thoroughly than farmers would do it; (3) it is difficult to determine accurately the expense of the spraying; (4) the idea is prevalent that the Station potatoes are given extra good care in order that large yields may be obtained.[10]

To satisfy this demand for experiments of a more practical kind the Station decided to conduct a series of farmers' business experiments so managed as to show the actual profit in spraying potatoes under farm conditions. This work was commenced in 1903 with six experiments.[11] In 1904, fourteen such experiments were made and in 1905 the same number. The results have been of such general interest, that it has been decided to make several of these business expriments each season during the remaining six years in which the potato spraying experiments are to be continued.

METHODS.

The methods employed have been essentially the same as in previous years. In the spring of 1905 the Station arranged with fourteen farmers in different parts of the State to keep an account of their spraying operations on potatoes. An accurate record was kept of all the expense of the spraying including labor, chemicals and wear of machinery. In each experiment strips of three to seven rows were left unsprayed for comparison. These rows received no bordeaux mixture but were treated with poison to protect the plants from bugs. In four of the experiments there was but a single unsprayed strip; in nine experiments there were two unsprayed strips; and in one experiment there were three of the unsprayed strips. Hence, so far as concerns the increase in yield

[10] For a discussion of these objections see Bulletin 221, pages 257–261.

[11] Details of the business experiments in 1903 were published in Bulletin 241, pp. 267–282; and those of the experiments in 1904 in Bulletin 264, pp. 116–152.

due to spraying, these fourteen experiments really included 23 separate tests. All work connected with the spraying was done by the farmers themselves in such manner as they deemed best.

In the fall, the tubers on one or more of the unsprayed rows were carefully weighed. The same was done with one or more sprayed rows on either side. In this manner it was determined how much the yield had been increased by spraying. In all except one case, a representative of the Station was present when the test rows were dug and assisted with the weighing. The length and width of the rows were carefully measured, the Station representative assisting with this, also. Accordingly we can vouch for the accuracy of the yields reported.

It was our intention to visit each of the experiments two or three times during the spraying season for the purpose of taking notes, but this was found impracticable for the three experiments in the northern part of the State. On this account there is a regrettable lack of information concerning the prevalence of blight and insects in some of the experiments.

The experiment fields varied in size from six to twenty-one acres, the total acreage of the fourteen experiments being 166⅔ acres. As far as practicable they were placed in localities where the potato is a leading farm crop. In eleven of the experiments the test rows were in plain view from a public road so that the results could be seen by passersby.

The method of spraying in the Hebron experiment was one we call the two-hose-and-three-men method. In the other thirteen experiments the spraying was done with horse sprayers of several different kinds covering three to seven rows at each passage.[12]

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[12] Nothing is said in this bulletin concerning the relative merits of different potato sprayers. It has been our aim to have the leading potato sprayers represented in the experiments, but this is not a comparative test of spraying machinery. The larger gain or larger net profit obtained in some experiments than in others is not necessarily due to a difference in the kind of sprayer used. It is impossible to make close comparisons because the conditions in the different experiments vary greatly. The Station is obliged to decline to answer the question, Which is the best potato sprayer? We can only say that there are now upon the market several good, practical potato sprayers. The excellent results obtained in the business experiments during the past three years are proof of this.

THE GOWANDA EXPERIMENT.

This experiment was made by E. T. Ryder, Gowanda, Cattaraugus county. Ten acres of potatoes, variety Rural New York No. 2, were sprayed with bordeaux and paris green four times on the following dates: June 28 and 29, July 7 and 8, July 14 and 15 and August 2 and 3. The spraying outfit used consisted of a one-horse, home-made, two-wheeled cart carrying a Spramotor barrel spray pump and a Spramotor potato spraying attachment rigged to cover three rows at a time with four nozzles per row. (See Plate III, fig. 1). The pumping was done by the driver. Water for making the bordeaux was conveniently obtained from a small stream at one end of the field.

Six rows 1150 feet long were left unsprayed. These rows were treated four times with paris green in water applied with the sprayer on the same dates that bordeaux and paris green were applied to the sprayed portion of the field. Bugs were kept well under control on the sprayed and unsprayed rows alike.

The items of expense of spraying the ten acres four times were as follows:

216	lbs. copper sulphate @ 15½c	$11.88
1½	bbl. lime @ $1	1.50
4½	gals. stock solution of arsenite of soda @ 16c	.72
14	lbs. paris green @ 25c	3.50
80	hrs. labor for man @ 15c	12.00
40	hrs. labor for horse @ 7½c	3.00
Wear on spraying outfit		5.00
	Total	$37.60

The total cost of spraying was $3.76 per acre or 94 cents per acre for each application.

As late as July 28 there was no apparent difference between the sprayed and unsprayed rows. During August late blight attacked the unsprayed rows causing considerable damage. Before the plants were killed by frost, on September 14, there was a marked contrast between the sprayed and unsprayed rows.

The test rows were dug and weighed October 6. Owing to lack of time only 500 feet of the rows was dug. The rows used for comparison were one of the middle two unsprayed rows, the second

sprayed row on one side and the first sprayed row on the other side. The yields were as follows:

Second sprayed row on the west, 326 lbs. marketable tubers.
First sprayed row on the east,[13] 196 lbs. marketable tubers.
Average of two sprayed rows, 261 lbs. marketable tubers.
One of the middle two unsprayed rows, 169 lbs. marketable tubers.
Yield, sprayed, 133 bu. 46 lbs. marketable tubers per acre.
Yield, unsprayed, 87 bu. 37 lbs. marketable tubers per acre.
Gain, 46 bu. 9 lbs. marketable tubers per acre.

Spraying increased the yield at the rate of 52.5 per ct.

The yield of small potatoes or culls was at the rate of 59 bu. 58 lbs. per acre for the sprayed and 52 bu. 17 lbs. per acre for the unsprayed, making a difference of 7 bu. 41 lbs. per acre in favor of the sprayed. Usually the greater yield of culls is on the unsprayed rows.

There was no loss from rot either on the sprayed or on the unsprayed rows.

At 60 cents per bushel, the market price of potatoes in Gowanda at digging time, 46 bu. 9 lbs. of potatoes would be worth $27.69. Substracting $3.76, the cost of spraying per acre, we have left *a net profit of* $23.93 *per acre.*

THE GAINESVILLE EXPERIMENT.

This experiment was made by Brainerd & Beaumont, Gainesville, Wyoming county, who conducted a similar experiment for the Station in 1904. A field of sixteen acres (variety, Sir Walter Raleigh and Carman No. 3 mixed) was sprayed seven times on the following dates: June 29-30, July 7-8, July 14-15, August 2, 10, 16 and 26. The sprayer used was the "Aroostook" power sprayer covering 5 rows at each passage.[14] Poison (arsenite of soda) was used with the bordeaux in the first five sprayings.

Five rows 240 feet long were left unsprayed. Although paris green was applied to these rows on the same dates that poison was used on the sprayed rows and twice more, between times, bugs caused slightly more damage here than on the sprayed rows. It

[13] As a general rule the second rather than the first sprayed row should be used, but it was not possible in this case as the second sprayed row had been dug previously by mistake.

[14] For an illustration of the sprayer used in the Gainesville experiment see Bulletin 264, Plate VII, fig. 1.

is unquestionably true that bugs are more easily controlled when the poison is used with bordeaux.

The expense account included the following items:

748 lbs. copper sulphate @ 5 4-5c	$43.38
580 " lime @ 3-4c	5.10
58 white arsenic @ 4 2-3c	2.71
118 " sal soda @ 1c	1.18
112 hrs. labor for man @ 15c	16.80
79 " labor for team @ 15c	11.85
Wear on sprayer	5.60
Total	$86.62

The total cost of spraying was $5.41 per acre or 77⅓ cents per acre for each application.

Mr. Brainerd reports that up to August 7 there were no signs of late blight. By August 16 the unsprayed rows were considerably blighted and there were traces of the disease on the sprayed rows also. The unsprayed rows were practically dead by September 1 while the sprayed rows remained green until frost which occurred on the night of September 13. Mr. Brainerd holds that the actual benefit from spraying is greater than experiments of this kind show. Small quantities of spray drift onto the unsprayed rows and furnish some protection against blight, so that they remain green longer than the unsprayed fields in the same locality. According to our observations this is usually the case and we believe that Mr Brainerd's opinion is a correct one.

The test rows were dug and weighed on October 4 with the following results:

Second sprayed row on the west, 217 lbs. marketable tubers.
Second sprayed row on the east, 217 lbs. maketable tubers.
Average for the two sprayed rows, 217 lbs. marketable tubers.
Middle unsprayed row, 153 lbs. marketable tubers.
Yield, sprayed, 225 bu. 2 lbs. marketable tubers per acre.
Yield, unsprayed, 157 bu. 40 lbs. marketable tubers per acre.
Gain, 67 bu. 22 lbs. marketable tubers per acre.

Spraying increased the yield of marketable tubers 42.7 per ct.

The yield of culls was 24 bu. 22 lbs. per acre for the sprayed and 43 bu. 33 lbs. per acre for the unsprayed making a difference of 19 bu. 11 lbs. per acre in favor of the unsprayed.

There was practically no loss from rot either on the sprayed or the unsprayed.

On the date of digging the test rows the market price of potatoes in Gainesville was 43 cents per bushel of 62 pounds. At this price the value of the increase would be $28.04 per acre. Subtracting from this $5.41, the cost of spraying, we have left *a net profit of* $22.63 *per acre.* However, the actual profit in this experiment was considerably greater than this. Most of the crop was stored and afterward sold at 58 cents per bushel and upward.

THE ARKPORT EXPERIMENT.

Conducted by Taylor Bros., Arkport, Steuben county. These gentlemen are extensive potato growers, growing and spraying 55 acres of potatoes in 1905. However, the experiment here described was confined to one field of six acres. The variety was Sir Walter Raleigh. The potatoes were sprayed four times — July 1, 6, 10 and 25. The machine used was a one-horse, Aspinwall power potato sprayer carrying eight nozzles and covering four rows at each passage. Bugs being exceedingly troublesome, paris green was used with the bordeaux in all five sprayings at the rate of one pound per acre.

Three unsprayed rows 1450 feet long were left as a check. These were treated with paris green as many times and on the same dates as the sprayed rows, but they were slightly more damaged by bugs than were the sprayed rows. Taylor Bros. state that bugs were unusually difficult to control. They found the paris green more effective when used with bordeaux than when used alone.

The expense of spraying six acres four times was as follows:

144 lbs. copper sulphate @ 6½c	$9.36
144 " lime @ ½c	.72
26 " paris green @ 20c	5.20
20 hrs. labor for man and horse @ 30c	6.00
Wear on sprayer	2.40
Total	$23.68

The total cost of spraying was $3.95 per acre or 98½ cents per acre for each application. However, when it is considered that four applications of paris green for bugs would have been required anyway it will be seen that the actual extra expense of the spraying for blight was only the cost of the copper sulphate which was $9.36 or $1.56 per acre.

Up to August 1 there was not even a trace of late blight in the experiment field. At that time there was no difference between the sprayed and unsprayed rows except that the latter seemed to have been slightly more injured by bugs. We did not see the experiment after August 1 and have no definite information as to the cause of the increased yield on the sprayed rows.

The potatoes having been planted early, matured early. The test rows were dug September 7. They were sorted and weighed by Mr. S. H. Cridler of Arkport, no representative of the Station being present. The yields were as follows:

Second sprayed row on the west, 882 lbs. marketable tubers.
Middle unsprayed row, 674 lbs. marketable tubers.
Yield, sprayed, 147 bu. marketable tubers per acre.
Yield, unsprayed, 112 bu. 20 lbs. marketable tubers per acre.
Gain, 34 bu. 40 lbs. marketable tubers per acre.

Spraying increased the yield of marketable tubers 30.8 per ct.

No record was kept of the yield of culls. There was no rot.

On October 12 the market price of potatoes in Arkport was 50 cents per bushel. At this price, 34⅔ bushels of potatoes would be worth $17.33. Subtracting $3.95, the cost of spraying, we have left *a net profit of* $13.39 *per acre.*

Owing to early planting, the potatoes must have been nearly mature before blight became epidemic. This probably explains the small gain in this experiment.

THE ATLANTA EXPERIMENT.

Conducted by T. S. Darling, Atlanta, Steuben county. As this experiment covered two fields of four acres each, of different varieties and planted at different times it was thought best to leave an unsprayed strip in each field. The spraying in both fields was done with a "Watson" one-horse, four-row power sprayer. In the earlier sprayings, only one nozzle was used while in the later sprayings two nozzles per row were used. We believe this a good practice. Water for making the bordeaux was hauled to the field in barrels on a wagon a distance of about one-half mile. A separate account was kept with each field.

Field No. 1.—This field contained four acres of the variety Carman No. 1. It was sprayed four times — July 7, 20, August 1 and 14. One nozzle per row was used in the first three sprayings

and two nozzles per row in the last one. In the first three sprayings paris green was applied with the bordeaux.

Three rows 335 feet long were left unsprayed. Paris green was applied to these rows frequently so that bugs did not injure them.

The items of expense were as follows:

110 lbs. copper sulphate @ 7c	$7.70
115 " lime	1.45
2½ " paris green @ 20c	.50
7½ " paris green @ 25c	1.88
10½ hrs. labor for man and horse @ 25c	2.63
Wear on sprayer	2.00
Total	$16.16

The total cost of spraying was $4.04 per acre or $1.01 per acre for each application.

The test rows were dug and weighed on September 29th, a Station representative assisting with the work.

The yields were as follows:

Second sprayed row on the north, 133 lbs. marketable tubers.
Second sprayed row on the south, 132 lbs. marketable tubers.
Average of two sprayed rows, 132½ lbs. marketable tubers.
Middle unsprayed row, 71 lbs. marketable tubers.
Yield, sprayed, 107 bu. 35 lbs. marketable tubers per acre.
Yield, unsprayed, 57 bu. 56 lbs. marketable tubers per acre.
Gain, 49 bu. 39 lbs. marketable tubers per acre.

Spraying increased the yield 85.7 per ct. There were but few rotten tubers.

The yield of culls was 9 bu. 15 lbs. per acre for the sprayed and 33 bu. 44 lbs. for the unsprayed, making a difference of 24 bu. 29 lbs. per acre in favor of the unsprayed. Owing to the premature death of the plants on the unsprayed rows many tubers failed to attain marketable size.

At 50 cents per bushel the market price of potatoes in Atlanta the day the test rows were dug, the value of the increase would be $24.82. Subtracting $4.04, the cost of spraying, we have left *a net profit of* $20.78 *per acre.*

Field No. 2.—This field also contained four acres of the variety Sir Walter Raleigh planted several days later than Field No. 1. It was sprayed only three times — July 18, August 1 and 24. One nozzle per row was used in the first two sprayings and two nozzles

per row in the last one. Paris green was applied with the bordeaux only in the first two sprayings.

Three rows 626 feet long were left unsprayed. These rows were treated with paris green frequently so that bugs did no harm, but in one application the plants were slightly injured by the paris green.

The expense of the spraying was as follows:

74 lbs. copper sulphate @ 7c	$5.18
75 " lime	1.00
7 " paris green @ 25c	1.75
7½ hrs. labor for man and horse @ 25c	1.88
Wear on sprayer	2.00
Total	$11.81

The total cost of spraying was $2.95 per acre or 98 cents per acre for each application.

The test rows were dug September 29 with the following results:

Second sprayed row on the north, 226 lbs. marketable tubers.
Second sprayed row on the south, 231 lbs. marketable tubers.
Average of two sprayed rows, 228½ lbs. marketable tubers.
Middle unsprayed row, 140 lbs. marketable tubers.
Yield, sprayed, 99 bu. 56 lbs. marketable tubers per acre
Yield, unsprayed, 61 bu. 14 lbs. marketable tubers per acre.
Gain, 38 bu. 42 lbs. marketable tubers per acre.

In this experiment, also, there was practically no loss from rot. Spraying increased the yield of marketable tubers 63.2 per ct.

The yield of culls was 5 bu. 31 lbs. per acre for the sprayed and fourteen bushels for the unsprayed, making a difference of 8 bu. 29 lbs. per acre in favor of the unsprayed.

At 50 cents per bushel the value of the increase in this experiment would be $19.35. After deducting $2.95, the cost of spraying we have left *a net profit of* $16.40 *per acre.*

Combining the results obtained in the two fields there is an average gain of 44 bu. 10 lbs. per acre and *an average net profit of* $18.59 *per acre.*

The gain in both these experiments seems to have been due chiefly to protection against late blight. There was no trace of the disease in either experiment on August 1, but it appeared soon after and wrought serious injury to the unsprayed rows. Mr.

Darling states that the sprayed rows lived about four weeks longer than the unsprayed. The contrast was very marked.

THE SPENCERPORT EXPERIMENT.

This experiment was made by F. E. Gott, Spencerport, Monroe county. Mr. Gott conducted a similar experiment for the Station in 1904. In 1905 the experiment field contained fourteen acres planted with three different varieties. Owing to washing out and rotting of the "seed" in several places the crop on about four acres was practically worthless. In spraying it was necessary to drive the sprayer over nearly the whole of the fourteen acres, but in going across the bare areas the spray was shut off. This makes it difficult to determine accurately the expense of the spraying. Mr. Gott is of the opinion that the total expense, $24.40, should be considered as being the result of spraying ten acres three times. This would make the total expense per acre $2.44 or 81 cents per acre for each application. The items are as follows:

108 lbs. copper sulphate @ 6¼c	$6.75
1 bbl. lime	1.25
48 hrs. labor for man @ 15c	7.20
24 " labor for team @ 30c	7.20
Wear on sprayer	2.00
Total	$24.40

The spraying outfit was the same one used in the 1904 experiment; namely, a home-made, two-horse rig spraying three rows at a time with one nozzle per row.[16] Two men are required to operate it — one to pump and one to drive. The dates of spraying were August 7, 23, 25 and September 6.

Three rows 664 feet long and of the variety White Giant were left unsprayed.

Before spraying was commenced one application of paris green was made, wherever needed, over the whole field including the unsprayed rows. Further than this no poison was required either on the sprayed or the unsprayed rows.

As late as September 1 there was no difference between the sprayed and unsprayed rows, but by September 15 there was a

[16] For an illustration of the spraying outfit used in the Spencerport experiment see Bulletin 264, Plate VII, fig. 2.

marked contrast, the unsprayed rows being practically dead while the sprayed rows were still green. On September 23 the test rows were photographed (See Plate V). At that time the unsprayed rows were dead and the stalks of the plants mostly dry while the nearby sprayed rows on the west still retained one-third to one-half their foliage. For some unexplained reason the sprayed rows on the east side of the unsprayed strip were considerably less green than those on the west. Still there was much contrast as is plainly shown in the photograph.

Not having an opportunity to examine the field after the outbreak of blight until September 23 the writers are in doubt as to the nature of the disease which killed the unsprayed rows. Tipburn and early blight were certainly factors and probably late blight, *Phytophthora infestans,* also, played an important part although there was little evidence of it on the plants September 23.

The test rows were dug October 30 and the yields found to be as follows:

Second sprayed row on the west, 468 lbs. marketable tubers.
Second sprayed row on the east, 278 lbs. marketable tubers.
Average of two sprayed rows, 373 lbs. marketable tubers.
Middle unsprayed row, 227 lbs. marketable tubers.
Yield, sprayed, 135 bu. 53 lbs. marketable tubers per acre.
Yield, unsprayed, 82 bu. 42 lbs. marketable tubers per acre.
Gain, 53 bu. 11 lbs. marketable tubers per acre.

Spraying increased the yield of marketable tubers 64.3 per ct. There was no rot worth mentioning either on the sprayed or unsprayed rows.

The yield of culls was at the rate of 10 bu. 53 lbs. per acre for the sprayed and 16 bu. 23 lbs. per acre for the unsprayed rows, making a difference of 5½ bushels per acre in favor of the unsprayed.

Why there should have been such a wide difference in yield between the two sprayed rows is not known. Mr. Gott states that so far as he knows the two rows had an equal chance in all respects. Although they were sprayed alike the west row remained green somewhat the longer.

At 60 cents per bushel, the market price at digging time, 53 bu. 11 lbs. of potatoes would be worth $31.91. Subtracting $2.44, the cost of spraying, there is left *a net profit of* $29.47 *per acre.*

As the bulk of the crop was sold within a short time after digging at an average price of about 70 cents per bushel, the actual net profit was about one-sixth greater than is shown by the figures given above.

THE CORTLAND EXPERIMENT.

This experiment was made by Geo. H. Hyde, Cortland, N. Y. It included six acres of potatoes in two fields. Three unsprayed rows were left in each field. The spraying was done with a "Watson" one-horse, four-row power sprayer like the one used in the Atlanta experiment. Both fields were sprayed five times, with one nozzle per row in the first three sprayings and two nozzles per row in the last two. The bordeaux used in the first three sprayings contained five pounds of copper sulphate and six pounds of lime to each fifty gallons (5-6-50 formula) while that used in the last two sprayings was of the 6-6-50 formula. In both fields paris green was used with the bordeaux only in the first two sprayings. The items of expense for spraying six acres five times were as follows:

300 lbs. copper sulphate @ 6c	$18.00
1 bbl. lime	1.30
22 lbs. paris green @ 18c	3.96
25 hrs. labor for man @ 15c	3.75
20 " labor for horse @ 12½c	2.50
Wear on sprayer	9.45
Total	$38.96

The total cost of spraying was $6.50 per acre or $1.30 per acre for each application.

It will be observed that the cost of spraying in this experiment is considerably higher than in the Atlanta experiment (page 137) in which the same kind of a sprayer was used and nearly the same acreage sprayed. This is chiefly owing to the larger quantity of copper sulphate used and the larger allowance for wear of sprayer.

Field No. 1.—This field contained four acres of potatoes of the variety World's Superior, planted May 15. The dates of spraying were July 7, 11, 27, August 9 and 21. Three rows 439 feet long were left unsprayed. Paris green was applied to these rows five times — three times with a powder gun and twice in the form of spray — the first two applications being made on July 7 and 11 the

same dates on which paris green was used with the bordeaux mixture on the sprayed rows.

The test rows were dug with a potato digger October 5. The yields were as follows:

Second sprayed row on the west, 458 lbs. marketable tubers.
Second sprayed row on the east, 467 lbs. marketable tubers.
Average of two sprayed rows, 462½ lbs. marketable tubers.
Yield, sprayed, 254 bu. 55 lbs. marketable tubers per acre.
Yield, unsprayed, 51 bu. 15 lbs. marketable tubers per acre.
Gain, 203 bu. 40 lbs. marketable tubers per acre.

The yield of culls was remarkably small being only 4 bu. 58 lbs. per acre for the sprayed and 9 bu. 55 lbs. per acre for the unsprayed.

There was no rot whatever in this field either on the sprayed or unsprayed rows. The crop as a whole was an unusually satisfactory one. The tubers were uniformly smooth, clean, of good size and shape and perfectly sound.

Field No. 2.—This field contained two acres of the variety Norcross, planted May 20. The dates of spraying were July 7, 11, 24, August 4 and 18. Three rows 831 feet long were left unsprayed. They were treated five times with paris green in the same manner and on the same dates as the unsprayed rows in Field No. 1. The test rows were dug October 5 with a potato digger. The yields were as follows:

Second sprayed row on the west, 604 lbs. marketable tubers.
Second sprayed row on the east, 649 lbs. marketable tubers.
Average of two sprayed rows, 626½ lbs. marketable tubers.
Middle unsprayed row, 138 lbs. marketable tubers.
Yield, sprayed, 82 bu. 25 lbs. marketable tubers per acre.
Yield, unsprayed, 40 bu. 11 lbs. marketable tubers per acre.
Gain, 142 bu. 14 lbs. marketable tubers per acre.

In this experiment there was a little rot and there was somewhat more of it on the sprayed than on the unsprayed rows. The small and rotten tubers were weighed together, the yields being 12 bu. 31 lbs. per acre for the sprayed and 10 bu. 38 lbs. per acre for the unsprayed.

Combining the results obtained in the two fields we have an average gain of 172 bu. 57 lbs. marketable tubers per acre. However, all of this gain should not be attributed to spraying. The con-

ditions in this experiment were unusual. The sprayer failing to arrive from the factory as soon as was expected, bugs became very numerous in both fields before any spraying could be done. The first spraying was made July 7 with bordeaux and paris green. A second spraying was made on July 11. These two applications checked the bugs so effectually that the sprayed rows required nc more poison during the remainder of the season. But on the unsprayed rows it was different. Although in both fields the unsprayed rows, also, were treated with paris green on July 7 and 11, by means of a powder gun, the bugs continued their depredations; and even by three additional applications of paris green (once with a powder gun and twice with a hand sprayer) the bugs were only partially controlled. In spite of all that could be done the unsprayed rows in both fields were ruined by bugs. Most of the damage was done by mature beetles which bit off the leaf stalks to such an extent that the ground was covered with the fallen leaves. Mr. Hyde is of the opinion that spraying drove the beetles to the unsprayed rows causing these rows to be more severely attacked than they would have been had no spraying been done. Such may have been the case. Our personal observations were too few to enable us to express a positive opinion on the subject. Whatever the true explanation, the fact stands out prominently that two applications of paris green with bordeaux gave full protection against bugs where five applications by ordinary methods utterly failed.

Neither early blight nor flea beetles were important factors in this experiment. Late blight probably hastened the death of the unsprayed rows, particularly in Field No. 2; but most of the injury was due to bugs.

Because of the uncertainty as to what part of the gain in this experiment should be credited to spraying, the results have not been used in making up the averages on page 161. Had this experiment been included, the average gain due to spraying in the business experiments would have been 55½ bushels per acre. Mr. Hyde is satisfied that the spraying was highly profitable. He believes that it doubled his yield.

THE CASSVILLE EXPERIMENT.

This experiment was conducted by P. S. Doolittle, Cassville, Oneida county. Eleven acres of potatoes, variety Carman No. 3.

were sprayed five times — July 11, 20, August 4, 18 and September 2. The sprayer used was an Aspinwall one-horse, four-row power sprayer carrying one nozzle per row in the first spraying and two nozzles per row in the other four. (Plate IV, fig. 1.) The bordeaux was made by the 6-6-50 formula and the water used in its preparation was obtained from a well at one corner of the field. One man pumped the water and made the bordeaux while another drove the sprayer. Paris green was used with the bordeaux only in the first two sprayings at the rate of one pound to 50 gallons. In 1904 a part of the field was in sod and the remainder grew corn. On each kind of ground four rows 525 feet long were left unsprayed. The unsprayed rows were treated twice with paris green in water at the same rate and on the same dates as the sprayed rows. Also, the application was made with the same sprayer. Bugs caused no material injury anywhere. Late blight was the principal enemy in this experiment. The unsprayed rows blighted much more than the sprayed rows although the latter were considerably injured. Toward the close of the season there was a marked contrast between the sprayed and unsprayed rows. Even at digging time (October 6) it was noticeable that the stalks of the unsprayed plants had been dead longer and were much drier than those on the sprayed rows.

The items of expense for spraying eleven acres five times were as follows:

317 lbs. copper sulphate @ 7c	$22.19
5 bu. lime @ 15c	.75
32 lbs. paris green @ 20c	6.40
78 hrs. labor for man @ 15c	11.70
34 " labor for horse @ 10c	3.40
Wear on sprayer	3.00
Total	$47.44

The total cost of spraying was $4.31 per acre or 86 cents per acre for each application.

Both sets of test rows were dug with a potato digger on October 6. The yields were as follows:

Test No. 1. Corn ground.

Second sprayed row on the north, 193¼ lbs. marketable tubers.
Second sprayed row on the south, 198 lbs. marketable tubers.
Average of two sprayed rows, 195⅝ lbs. marketable tubers.

One of middle two unsprayed rows, 128¾ lbs. marketable tubers.
Yield, sprayed, 90 bu. 9 lbs. marketable tubers per acre.
Yield, unsprayed, 59 bu. 20 lbs. marketable tubers per acre.
Gain, 30 bu. 49 lbs. marketable tubers per acre.

The yield of small and rotten tubers was 39½ bushels per acre for the sprayed and 34½ bushels per acre for the unsprayed.

Test No. 2. Sod ground.

Second sprayed row on the north, 176¼ lbs. marketable tubers.
Second sprayed row on the south, 131 lbs. marketable tubers.
Average of two sprayed rows, 153⅝ lbs. marketable tubers.
One of the middle two unsprayed rows, 75 lbs. marketable tubers.
Yield, sprayed, 70 bu. 47 lbs. marketable tubers per acre.
Yield, unsprayed, 34 bu. 34 lbs. marketable tubers per acre.
Gain, 36 bu. 13 lbs. marketable tubers per acre.

The yield of small and rotten tubers was 50 bu. 10 lbs. per acre for the sprayed and 26 bu. 44 lbs. per acre for the unsprayed.

Combining the results obtained in the two fields we have an average gain of 33 bu. 31 lbs. marketable tubers per acre. This is a comparatively small gain, but when the size of the yields is taken into consideration the showing made is a good one. Spraying increased the yield 71.4 per ct. At the time of digging the test rows the market price of potatoes in Utica was 75 cents per bushel. This makes the value of the increase $25.14 per acre. Subtracting $4.31, the cost of spraying, there is left *a net profit of* $20.83 *per acre.*

The loss from rot in this experiment was considerable and it was certainly greater on the sprayed than on the unsprayed rows. An explanation of this is given on page —. Had there been no unsprayed rows for comparison many would have pronounced the spraying a failure, while as a matter of fact it was a decided success.

THE VERONA MILLS EXPERIMENT.

This experiment was made by F. G. Rathbun, Verona Mills, Oneida county. Eleven acres of potatoes, in two fields, were sprayed five times. One field contained seven acres and the other four. In both, the variety was Green Mountain. The dates of spraying were as follows: June 24-29, July 12-15, July 24-31, August 9-14 and August 19-22. Poison was used with the bordeaux in the first three sprayings. Some unsprayed rows were

left in each field and these were treated with poison four times; yet in the seven-acre field bugs injured the unsprayed rows somewhat more than the sprayed rows. The sprayer used was a Spramotor one-horse, five-row power sprayer carrying thirteen nozzles. (Plate III, fig. 2.) The bordeaux was made with six pounds of copper sulphate and seven pounds of prepared lime to fifty gallons. The expense of spraying the eleven acres five times included the following items:

258	lbs. copper sulphate @ 6c	$15.48
301	" lime @ 1c	3.01
40	" paris green @ 16c	6.40
6½	" white arsenic @ 8c	.52
98	hrs. labor for man @ 15c	14.70
83	" labor for horse @ 5c	4.15
Interest and wear on sprayer		11.00
Total		$55.26

The total cost of spraying was $5.02 per acre or $1 per acre for each application.

In both fields the unsprayed rows died somewhat earlier than the sprayed owing chiefly to the ravages of late blight. Neither flea beetles nor early blight entered into the problem to any extent.

The test rows in both fields were dug by hand October 4. The results were as follows:

Seven-acre field.—Five rows 477 feet long were left unsprayed. The yields in this field were as follows:

Third sprayed row on the west, 372 lbs. marketable tubers.
Third sprayed row on the east, 327 lbs. marketable tubers.
Average of two sprayed rows, 349½ lbs. marketable tubers.
Middle unsprayed row, 286½ lbs. marketable tubers.
Yield, sprayed, 177 bu. 19 lbs. marketable tubers per acre.
Yield, unsprayed, 145 bu. 21 lbs. marketable tubers per acre.
Gain, 31 bu. 58 lbs. marketable tubers per acre.

There was a little rot on all of the rows and apparently no difference between the sprayed and unsprayed. The yield of small and rotten tubers was 26 bu. 53 lbs. per acre for the sprayed and 33 bu. 29 lbs. per acre for the unsprayed.

Four-acre field.—There were four unsprayed rows 705 feet long. The yields in this field were as follows:

Second sprayed row on the east, 532 lbs. marketable tubers.
One of the middle unsprayed rows, 338 lbs. marketable tubers.

Yield, sprayed, 182 bu. 39 lbs. marketable tubers per acre.
Yield, unsprayed, 116 bu. 2 lbs. marketable tubers per acre.
Gain, 66 bu. 37 lbs. marketable tubers per acre.

The loss from rot was practically the same as in the seven-acre field. There was no noticeable difference between the amount of rot on the unsprayed rows and that on the sprayed rows. The yield of small and rotten tubers was 11 bu. 40 lbs. per acre for the sprayed and 13 bu. 44 lbs. per acre for the unsprayed.

The average gain per acre in the two fields was 49 bu. 17 lbs. worth $32.03 (at 65 cents per bushel which was the market price at digging time). After deducting the cost of spraying, $5.02, there remains *an average net profit of* $27.01 *per acre.*

THE CHATEAUGAY EXPERIMENT.

This experiment was made by Oliver Smith & Son, Chateaugay, Franklin county. It included three fields of potatoes having a total area of 17 acres. Some unsprayed rows were left in each field. The sprayer used was an Iron Age one-horse, four-row power sprayer carrying one nozzle per row. The bordeaux was prepared by the 6-6-50 formula. Most of the water required was conveniently obtained from a small stream which ran between the larger two fields. The items of expense for spraying the entire seventeen acres (fifteen acres five times and two acres seven times) were as follows:

200 lbs. copper sulphate[17] @ 5½c	$11.00
150 " copper sulphate @ 6c	9.00
175 " copper sulphate @ 8c	14.00
2 bbl. lime @ $1.10	2.20
36 lbs. paris green @ 18c	6.48
57¾ hrs. labor for man and horse @ 25c	14.44
10½ " labor for extra man @ 15c	1.58
Wear of sprayer	10.00
Total	$68.70

The cost of spraying in this experiment was 77 cents per acre for each application.

[17] The expense account calls for more copper sulphate than was actually used in the spraying. A barrel of stock solution containing 150 pounds of copper sulphate broke and a considerable quantity was lost.

The two-acre field.—The potatoes in this field were of the variety Sulphic Beauty and planted May 15. They were sprayed seven times — July 3, 8, 22, August 1, 17, 28 and September 2. The total quantity of bordeaux used was 650 gallons. Paris green was used with the bordeaux twice; viz., on July 8 (two pounds per acre) and July 22 (one pound per acre). Three rows 323 feet long were left unsprayed. Paris green in water was applied to these rows twice (July 7 and 20) by means of a knapsack sprayer. The chief enemy was late blight which caused the death of the unsprayed rows about September 1 while the sprayed rows were still quite green on September 13 when they were killed by frost. No damage was done by bugs. The test rows were dug by hand September 22 with the following results:

Second sprayed row on the east, 382 lbs. marketable tubers.
Second sprayed row on the west, 357 lbs. marketable tubers.
Average of two sprayed rows, 369½ lbs. marketable tubers.
Middle unsprayed row, 282 lbs. marketable tubers.
Yield, sprayed, 276 bu. 49 lbs. marketable tubers per acre.
Yield, unsprayed, 211 bu. 16 lbs. marketable tubers per acre.
Gain, 65 bu. 33 lbs. marketable tubers per acre.

It was plain that spraying had checked the rot. There was practically no rot on either sprayed row while on the unsprayed row rotten tubers were frequent. The yield of small and rotten tubers was 24 bu. 32 lbs. per acre for the sprayed and 69 bu. 28 lbs. per acre for the unsprayed.

The nine-acre field.—The variety in this field was Enormous No. 9, planted May 18. They were given five sprayings, the total quantity of bordeaux used being 1,755 gallons. The dates of spraying were — July 10, 26, August 14-17, 28 and September 2. Paris green was used in the first two sprayings — seven pounds on July 10 and fifteen pounds on July 26. The three unsprayed rows, 1,419 feet long, were treated with paris green in water on the same dates. Toward the close of the season the unsprayed rows were plainly inferior to the adjacent sprayed rows. They died about two weeks earlier. In fact, the sprayed rows were still partly green when frost came. The test rows were dug by hand September 23 and the following yields obtained:

Second sprayed row on the east, 1,382 lbs. marketable tubers.
Second sprayed row on the west, 1,540½ lbs. marketable tubers.

Average of two sprayed rows, 1,461 lbs. marketable tubers.
Middle unsprayed row, 906 lbs. marketable tubers.
Yield, sprayed, 235 bu. 59 lbs. marketable tubers per acre.
Yield, unsprayed, 156 bu. marketable tubers per acre.
Gain, 79 bu. 59 lbs. marketable tubers per acre.

Rotten tubers were much more frequent on the unsprayed row than on the sprayed rows, but the loss was not great in either case. The yield of small and rotten tubers was 21 bu. 26 lbs. per acre for the sprayed and 46 bu. 31 lbs. per acre for the unsprayed. Most of the difference was in rotten tubers.

The six-acre field.—This field, also, was of the variety Enormous No. 9. The plants were sprayed five times — July 27, August 17-18, 26, September 2 and 9. In all, 1,650 gallons of bordeaux were used on this field. Paris green was applied only once; viz., in the first spraying when eight pounds were used. There were three unsprayed rows 688 feet long and these received an application of paris green in water on the same date. Being so late planted (June 8) the potatoes in this field had not nearly finished their growth when frost came September 13. The unsprayed rows were already commencing to die, but the sprayed rows were in full foliage. Had not frost come so early the yields in this field would have been larger and also the gain due to spraying larger. The test rows were dug with a potato digger on October 10, the yields being as follows:

Second sprayed row on the east, 332 lbs. marketable tubers.
Second sprayed row on the west, 381 lbs. marketable tubers.
Average of two sprayed rows, 356½ lbs. marketable tubers.
Middle unsprayed row, 251 lbs. marketable tubers.
Yield, sprayed, 118 bu. 50 lbs. marketable tubers per acre.
Yield, unsprayed, 83 bu. 40 lbs. marketable tubers per acre.
Gain, 35 bu. 10 lbs. marketable tubers per acre.

There was no rot of any account except at the north end where hog manure had been spread. Here, there was some rot but decidedly more on the unsprayed row than on the sprayed. The yield of small and rotten tubers was 9 bu. 10 lbs. per acre for the sprayed and 23 bu. per acre for the unsprayed.

Combining the results obtained in the three fields we have an average gain of 60 bu. 14 lbs. of marketable tubers per acre. On the average, spraying increased the yield 40 per ct. The gain is

all the result of spraying, there having been no interference by bugs. On September 22 and 23 when the test rows in the first two fields were dug, the market price of potatoes in Chateaugay was 25 cents per bushel; on October 10 when the test rows in the third field were dug the price had risen to 40 cents per bushel. Even at these low prices *the average net profit in the Chateaugay experiment was* $13.50 *per acre.* The actual profit was considerably greater than this. The entire crop was stored. Under date of December 21 Mr. Smith wrote that 2,200 bushels had been sold on November 1 at 70 cents per bushel while the remainder of the crop was still in storage and keeping well.

THE PERU EXPERIMENT.

This experiment was made by Datus Clark, Peru, Clinton county, who made a similar experiment for the Station in 1904. A field of ten acres was sprayed four times — July 24, August 8, 19 and September 8. In the second and third sprayings only 8 acres were sprayed each time, so that in reality the total area sprayed was only 36½ acres. The spraying was done with the same sprayer used in 1904; namely, an Aroostook two-horse, six-row sprayer with one nozzle per row. Water for making the bordeaux was obtained from a river at the north end of the field.

As there were no bugs to fight no poison was used. There were two varieties of potato — Ironclad and World's Fair, and three unsprayed rows were left in each variety.

The expense of the spraying included the following items:

132 lbs. copper sulphate @ 8c	$10.56
88 " lime @ 1c	.88
23½ hrs. labor for man @ 15c	3.53
19½ " labor for term @ 25c	4.88
Wear on sprayer	4.00
Total	$23.85

The cost of spraying was 65½ cents per acre for each application.

A large part of the field needs underdrainage badly and as the season was an extremely wet one the conditions were very unfavorable for a crop of potatoes. On the wetter portion of the field, planted with World's Fair, the plants made a weak growth, blighted

badly and died early in spite of spraying. On the drier portion of the field the variety Ironclad did considerably better. There was a rank growth of vines which did not blight until late in the season The test rows were dug by hand October 11.

Test No. 1. Ironclad.—The unsprayed rows were 773 feet long. Up to the time of digging there had been no frost and the sprayed plants although much blighted still retained about one-fifth their foliage. The unsprayed rows were now dead but there had been no marked difference in appearance between the sprayed and unsprayed rows until within a few days. The yields were as follows:

Second sprayed row on the west, 457½ lbs. marketable tubers.
Middle unsprayed row, 303 lbs. marketable tubers.
Yield, sprayed, 143 bu. 21 lbs. marketable tubers per acre.
Yield, unsprayed, 94 bu. 56 lbs. marketable tubers per acre.
Gain, 48 bu. 35 lbs. marketable tubers per acre.

On both rows there was a large amount of rot, somewhat more on the unsprayed row than on the sprayed one. The yield of small and rotten tubers was 60 bu. 57 lbs. per acre for the sprayed and 71 bu. 36 lbs. per acre for the unsprayed.

Test No. 2. World's Fair.—The unsprayed rows were 633 feet long. Both the sprayed and the unsprayed plants had been dead for some time. The yields were as follows:

Second sprayed row on the west, 109½ lbs. marketable tubers.
Middle unsprayed row, 47 lbs. marketable tubers.
Yield, sprayed, 41 bu. 53 lbs. marketable tubers per acre.
Yield, unsprayed, 18 bu. marketable tubers per acre.
Gain, 23 bu. 53 lbs. marketable tubers per acre.

Here, also, there was much rot, the sprayed row showing a little more than the unsprayed. The yield of small and rotten tubers was 26 bu. 11 lbs. per acre for the sprayed and 24 bu. 17 lbs. per acre for the unsprayed.

Combining the results obtained in the two tests there is an average gain of 36 bu. 14 lbs. per acre. In one test spraying increased the yield 51.2 per ct. and in the other 132.6 per ct. making an average of 91.9 per ct.

At the time of digging the test rows there was no market for potatoes in Peru, but a few days later the market opened at 55 cents per bushel. At this price 36 bu. 14 lbs. of potatoes would be worth

$19.93. After deducting the cost of spraying, $2.62, there remains *a net profit of* $17.31 *per acre.*

Notwithstanding the fact that there was much rot on the sprayed rows in both tests and an extremely low yield in one test the spraying was successful and profitable. However, had there been no unsprayed rows for comparison it would have been pronounced a flat failure. This experiment shows the unreliability of conclusions drawn from results obtained in fields where there are no check rows. They who wish to learn definitely the benefit from spraying must leave unsprayed rows for comparison.

THE HEBRON EXPERIMENT.

This experiment was conducted by Walter B. Shaw, Hebron, Washington county. The conditions were not entirely suitable for such an experiment and Mr. Shaw was reluctant about undertaking it, but finally consented as no better location could be found. Very little potato spraying has been done in Washington county.

Six acres of potatoes, variety unknown, were sprayed twice very thoroughly by what we call the two-hose-and-three-men method. A Myers barrel spray pump was mounted in a fifty-gallon barrel drawn through the field on a one-horse cart. One man on the cart drove and worked the pump while two other men walking behind the cart directed the nozzles attached at the ends of two long leads of hose from the spray pump. Four rows were sprayed at each passage through the field. The dates of spraying were August 2 and August 25-26. The bordeaux was prepared by the 6-6-54 formula and water for making it was obtained from a brook at one side of the field. Paris green was used with the bordeaux in the first spraying but not in the second. On the unsprayed rows, of which there were two sets of three rows each, paris green was applied August 3 by means of a powder gun. Owing to the delay in receiving the copper sulphate it was necessary to make one application of paris green over the entire field, check rows included, before any spraying was done. This application was made with a powder gun.

Both on the sprayed and unsprayed rows bugs were kept under control. It was plain that the paris green had been more effective

where applied with bordeaux than where applied dry by means of a powder gun. Still there were not enough bugs on the unsprayed rows to warrant a second application of poison. Flea beetles were quite plentiful and, as usual, injured the unsprayed rows more than the sprayed. Late blight appeared about August 25. It spread slowly. From the time of the first spraying on, the foliage of the sprayed rows was better than that of the unsprayed rows. Toward the close of the season the difference became quite marked. At the time of digging the test rows, September 27, there had been no frost and many of the sprayed plants still retained much of their foliage while the unsprayed plants in both tests were dead.

The items of expense for spraying six acres of potatoes twice were as follows:

94 lbs. copper sulphate @ 6¾c	$6.35
92 " lime @ 1c	.92
7 " paris green[18] @ 16c	1.12
74 hrs. labor for man[19] @ 15c	11.10
26 " labor for horse[20] @ 10c	2.60
Use of sprayer (hired)	2.05
Total	$24.14

The total cost of spraying was $4.02 per acre or $2.01 per acre for each application which is a little more than twice the average cost in the other twelve experiments. The method of spraying employed in this experiment is expensive because it requires so much man labor. Of course the spraying can be done very thoroughly but it is doubtful if the gain is proportional to the extra expense. We are confident that, in most cases, horse sprayers with stationary nozzles will give larger net profit. On steep hillsides, such as were encountered in this experiment, it may be possible to spray by this method where a sprayer with stationary nozzles could not be used.

Both sets of test rows were dug by hand September 27 with the following results:

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[18] This does not include paris green used before spraying was commenced.

[19] Includes four hours consumed in damming brook and getting things ready; also four hours going after sprayer and returning it.

[20] Includes four hours consumed in going after sprayer and returning it.

Test No. 1.—The unsprayed rows were 286 feet long. The following yields were obtained:

Second sprayed row on the west, 163 lbs. marketable tubers.
Second sprayed row on the east, 126½ lbs. marketable tubers.
Average of two sprayed rows, 144¾ lbs. marketable tubers.
Middle unsprayed row, 99¼ lbs. marketable tubers.
Yield, sprayed, 133 bu. 39 lbs. marketable tubers per acre.
Yield, unsprayed, 91 bu. 38 lbs. marketable tubers per acre.
Gain, 24 bu. 1 lb. marketable tubers per acre.

There were a few rotten tubers on the unsprayed row but none on the sprayed rows. The yields of small and rotten tubers were 15 bu. per acre for the sprayed and 20 bu. 19 lbs. per acre for the unsprayed.

Test No. 2.—The unsprayed rows were 704 feet long. The yields were as follows:

Second sprayed row on the west, 303¼ lbs. marketable tubers.
Second sprayed row on the east, 280 lbs. marketable tubers.
Average of two sprayed rows, 291⅝ lbs. marketable tubers.
Middle unsprayed row, 193½ lbs. marketable tubers.
Yield, sprayed, 109 bu. 21 lbs. marketable tubers per acre.
Yield, unsprayed, 72 bu. 34 lbs. marketable tubers per acre.
Gain, 36 bu. 47 lbs. marketable tubers per acre.

As regards rot, the conditions were about the same here as in Test No. 1; viz., but little on the unsprayed and none on the sprayed. The yield of small and rotten tubers was 16 bu. 58 lbs. for the sprayed and 24 bu. per acre for the unsprayed.

Combining the results obtained in the two tests there is an average gain of 39 bu. 24 lbs. marketable tubers per acre. The average percentage of gain was 48.2 per ct.

On the date of digging the test rows the market price of potatoes at Rupert, Vt., the nearest shipping point, was 40 cents per bushel. At this price the gain of 39 bu. 24 lbs. would be worth $15.66. After deducting the cost of spraying, $4.02, there remains ***a net profit of*** $11.64 ***per acre.*** Probably the actual profit will be greater than this. Up to the present writing (December 23) only one load has been sold at 65 cents per bushel of 65 pounds. The remainder of the crop is in storage and seems to be keeping well.

THE SYOSSET EXPERIMENT.

This experiment was conducted by John S. Burke, Syosset, Long Island. Two fields of potatoes were sprayed—one of ten acres planted with three different varieties and one of eleven acres planted

throughout with the variety Green Mountain. In the latter field two four-row strips were left unsprayed. A part of the 21 acres was sprayed four times, a part three times and a part twice, the total amount of spraying being equal to 66½ acres sprayed once. The spraying was done with a Spramotor hand-power pump mounted on the truck of a discarded Aspinwall sprayer and rigged to spray four rows at a time with three nozzles for each of the two outside rows and two nozzles for each of the two inside rows. The items of the expense of the spraying were as follows:

622 lbs. copper sulphate @ 6c	$37.32
2 bbl. lime @ $1.35	2.70
58 lbs. paris green @ 15c	8.70
48¾ hrs. labor for man @ 15c	7.32
48¾ " labor for horse @ 20c	9.75
Man and team hauling water	19.00
Wear on sprayer	5.00
Total	$89.79

The cost per acre for each spraying was $1.36½. This high cost is largely due to the expense of hauling water to the field. Although the work was light, the team while thus employed was not available for any other purpose so it is necessary to charge for full time.

In the eleven-acre field containing the two strips of unsprayed rows the plants made a luxuriant growth and seemed to be doing well until about the middle of July when they were seriously injured by drought. On July 20 Mr. Burke wrote that the crop had been so much injured by drought that he thought it might not pay to spray any more. Up to that time there seemed to be no benefit from the spraying. In fact Mr. Burke was of the opinion that the unsprayed rows were superior to the sprayed ones. On July 22 rain came and at the same time flea beetles appeared in swarms. After this rain the plants revived and another spraying was made early in August. From the time of the outbreak of flea beetles the sprayed rows made a better appearance than the unsprayed. Probably the increased yield on the sprayed rows was chiefly owing to the better protection against flea beetles. Early blight did not enter into the problem to any extent and late blight appeared only at the close of the season. Bugs were kept well under control both on the sprayed and the unsprayed rows

The dates of spraying the test rows were June 26, July 6 and August 7. Paris green was applied only in the first spraying and the unsprayed rows were treated with poison on the same date.

Test No. 1.—The rows in this test were 874 feet long. They were dug September 27 and the following yields obtained:

Second and third sprayed rows on the north, 1,287 lbs. marketable tubers.
Second and third sprayed rows on the south, 1,329 lbs. marketable tubers.
Average yield for two sprayed rows, 1,308 lbs. marketable tubers.
Middle two unsprayed rows, 1,104 lbs. marketable tubers.
Yield, sprayed, 197 bu. 30 lbs. marketable tubers per acre.
Yield, unsprayed, 166 bu. 42 lbs. marketable tubers per acre.
Gain, 30 bu. 48 lbs. marketable tubers per acre.

The yield of culls was at the rate of 10 bu. 12 lbs. per acre for the sprayed and 16 bu. 18 lbs. per acre for the unsprayed. There was a little rot on the sprayed rows, but somewhat more on the unsprayed.

Test No. 2.—Here, the test rows were 674 feet long. The sprayed rows on the north were given three sprayings as in Test No. 1, but those on the south received only two sprayings—June 26 and July 6. The test rows were dug September 27 with the following results:

Second and third sprayed rows on the north, 604 lbs. marketable tubers.
Second and third sprayed rows on the south, 637 lbs. marketable tubers
Average yield for two sprayed rows, 620½ lbs. marketable tubers.
Middle two unsprayed rows, 420 lbs. marketable tubers.
Yield, sprayed, 126 bu. 35 lbs. marketable tubers per acre.
Yield, unsprayed, 85 bu. 41 lbs. marketable tubers per acre.
Gain, 40 bu. 54 lbs. marketable tubers per acre.

The yield of culls was 14 bu. 47 lbs. per acre for the sprayed rows and 5 bu. 12 lbs. per acre for the unsprayed. On the sprayed as well as the unsprayed rows there was considerable loss from rot.

Why the rows on the south, sprayed only twice, yielded more than those on the north which were sprayed three times is not known. Mr. Burke states that on the whole the portion of the field sprayed twice (about four acres) did not yield as well as the portion sprayed three times.

Combining the results obtained in the two tests the average gain due to spraying in this experiment is 35 bu. 51 lbs. per acre. At

60 cents per bushel[21] this gain would be worth $21.51. Deducting $4.10, the cost of three sprayings, there remains *a net profit of* $17.41 *per acre.*

THE MATTITUCK EXPERIMENT.

This experiment was conducted by W. H. Satterly, Mattituck, Long Island, who made a similar experiment for the Station in 1904. Sixteen and two-thirds acres of potatoes, variety Green Mountain, were sprayed with a one-horse "Schanck" sprayer the same one used in the 1904 experiment. Two strips of seven rows each were left unsprayed. The entire sixteen and two-thirds acres were sprayed seven times—June 24-26, July 4-5, July 10-12, July 17, July 25-26, August 2 and August 10-11. About one-half the field was given an additional spraying July 22. This makes the total amount of spraying done equivalent to spraying 114⅔ acres once. The expense account included the following items:

540	lbs. copper sulphate @ 6c.	$32.40
360	" lime @ 1c	3.00
112	" paris green @ 15c.	16.80
74½	hrs. labor for man @ 20c.	14.90
74½	" labor for boy @ 10c.	7.45
74½	" labor for horse @ 10c.	7.45
Wear and repairs on sprayer		10.00
Total		$92.60

The total cost of spraying was $5.55 per acre or 74 cents per acre for each application.

The bordeaux mixture was of the 6-4-50 formula, the total quantity used being 4,500 gallons which is at the rate of a little more than 39 gallons per acre at each application. By comparing these figures with those given for the experiment in 1904 (Bul. 264, p. 143) it will be seen that the quantity per acre per application was one-half greater than in 1904. This difference is chiefly the result of spraying fewer rows at a time. In 1904 eight rows were covered at each passage in most of the spraying, while in 1905 the sprayer was driven over every fifth row. This also accounts for the increased expense of spraying in 1905.

[21] At the time of digging the test rows Mr. Burke was selling potatoes in the 103d St. (New York) market at $2 to $2.25 per barrel of 170 pounds. Allowing thirty cents per barrel for marketing, the net returns would be $1.70 to $1.95 per barrel which is somewhat more than sixty cents per bushel.

Paris green was used with the bordeaux not uniformly over the whole field, but whenever and wherever needed in the first, third, fifth and sixth sprayings and in the extra spraying of July 22. In all, 112 pounds of paris green were used. Perhaps the quantity was unnecessarily large. On the unsprayed rows, one application of paris green made June 26 was sufficient to prevent injury by bugs.

An examination of the experiment was made July 11. At that time there was no appreciable difference between the sprayed and unsprayed rows. On the unsprayed rows in the north test it was easy to find leaves affected with late blight and occasionally specimens of the disease were found also on the sprayed rows. Mr. Satterly states that he first found late blight July 5. Fortunately, the weather conditions during the greater part of July were unfavorable to blight so that an epidemic of the disease was avoided, but it made steady progress and in August did considerable damage. About July 22 swarms of flea beetles appeared and became an important factor in the experiment. There was also some early blight.

The test rows were dug on October 10 with a potato digger.

North test.—In the portion of the field in which this test was located the previous crop was hay. The test rows were 360 feet long. The yields were as follows:

Second sprayed row on the north, 469½ lbs. marketable tubers.
Second sprayed row on the south, 412 lbs. marketable tubers.
Average of two sprayed rows, 440¾ lbs. marketable tubers.
Middle unsprayed row, 329 lbs. marketable tubers.
Yield, sprayed, 296 bu. 15 lbs. marketable tubers per acre.
Yield, unsprayed, 221 bu. 9 lbs. marketable tubers per acre.
Gain, 75 bu. 6 lbs. marketable tubers per acre.

The yield of culls (small sound tubers) was at the rate of 16 bu. 48 lbs. per acre for the sprayed and 22 bu. 11 lbs. for the unsprayed. On the unsprayed row there was some rot, but on the sprayed rows none.

South test.—This test was located in a portion of the field which grew potatoes in 1904. The rows were 348 feet long. The yields were as follows:

Second sprayed row on the north, 281 lbs. marketable tubers.
Third sprayed row on the south,[a] 296½ lbs. marketable tubers.

[a] The second sprayed row on the south fell in a dead furrow.

FIG. 1.— USED IN GOWANDA EXPERIMENT.

FIG. 2.— USED IN VERONA MILLS EXPERIMENT.

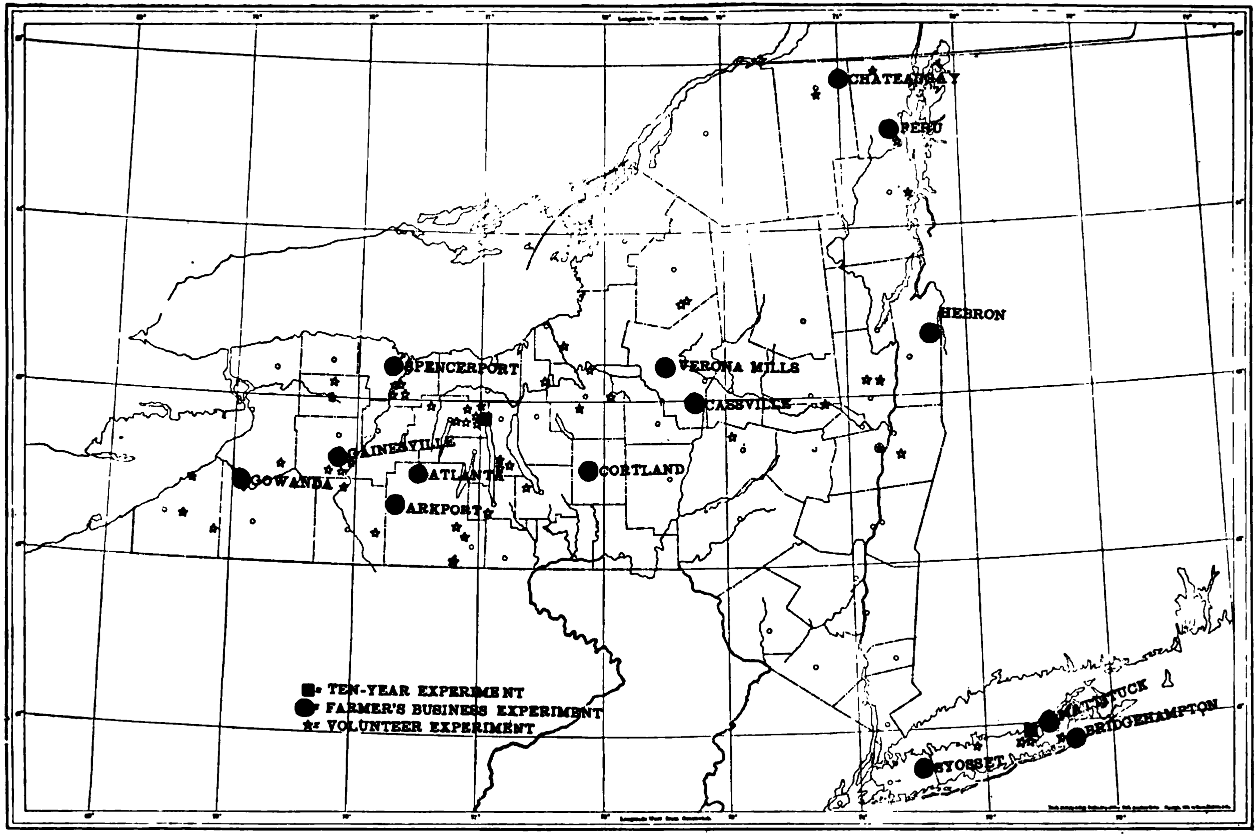
PLATE III.— SOME SPRAYERS USED IN EXPERIMENTS.

FIG. I.— SPRAYER USED IN THE CASSVILLE EXPERIMENT.

FIG. 2.—RESULTS IN VOLUNTEER EXPERIMENT NO. 42.

PLATE IV.

PLATE V.—THE SPENCERPORT EXPERIMENT.
Three rows through the center unsprayed. Photographed Sept. 23.



MAP I.—LOCATION OF POTATO SPRAYING EXPERIMENTS IN 1905.

Average of two sprayed rows, 288¾ lbs. marketable tubers.
Middle unsprayed row, 241 lbs. marketable tubers.
Yield, sprayed, 200 bu. 47 lbs. marketable tubers per acre.
Yield, unsprayed, 167 bu. 35 lbs. marketable tubers per acre.
Gain, 33 bu. 12 lbs. marketable tubers per acre.

The yield of culls was at the rate of 18 bu. 57 lbs. per acre for the sprayed and 18 bu. 5 lbs. for the unsprayed. In this test the unsprayed as well as the sprayed rows were free from rot. Most of the gain on the sprayed rows was due to protection against flea beetles and early blight.

Combining the results obtained in the two tests we have an average gain of 54 bu. 9 lbs. marketable tubers per acre, worth at the time of digging, $32.49. After subtracting the cost of spraying, $5.55 there remains *a net profit of* $26.94 *per acre.*

THE BRIDGEHAMPTON EXPERIMENT.

E. E. Halsey, Bridgehampton, Long Island, conducted this experiment. Eighteen acres of potatoes, mostly of the variety Carman No. 1, were sprayed eight times between June 13 and August 8. Two strips of four unsprayed rows each were left for checks. The spraying was done with an E. C. Brown, two-horse, five-row, power sprayer carrying one nozzle per row.

The bordeaux was of the usual 6-4-50 formula applied at the average rate of about 55 gallons per acre for each application. Arsenite of soda (prepared by boiling together one pound of white arsenite and four pounds of sal soda in one gallon of water) was used with the bordeaux in every spraying. On the unsprayed rows paris green was applied twice (June 24 and July 8) by means of a powder gun.

The items of expense for spraying 18 acres 8 times were as follows:

900 lbs. copper sulphate @ 6½c	$58.50
5 bbl. lime @ 1.45	7.25
34 lbs. white arsenic @ 15c	5.10
150 " sal soda @ 1½c	2.25
8 days labor for man @ $1.50	12.00
8 " labor for team @ $3.50	28.00
Wear on sprayer	10.00
Total	$123.10

In this experiment the total expense of spraying was $6.84 per acre or 85½ cents per acre for each application.

On July 11 when one of the writers visited the experiment field the unsprayed rows were apparently in as good condition as the sprayed rows. However, close examination revealed traces of late blight on the unsprayed rows. A month later (August 12) the unsprayed rows were nearly dead with late blight and the sprayed rows also were much affected and going down rapidly. Flea beetles which appeared in large numbers about July 22 added their injury to that done by blight. In the north test the sprayed rows outlived the unsprayed ones about two weeks, but in the south test the difference was less. Bugs were kept well under control on the unsprayed rows as well as on the sprayed ones. The test rows were dug on August 26 with a potato digger and the following results obtained:

North test.—Eighteen rows required to make an acre. The yields were as follows:

Two sprayed rows,[23] 2,044 lbs. marketable tubers.
Middle two unsprayed rows, 2,007 lbs. marketable tubers.
Yield, sprayed, 306 bu. 36 lbs. marketable tubers per acre.
Yield, unsprayed, 3 1 bu. 3 lbs. marketable tubers per acre.
Gain, 24 bu. marketable tubers per acre.

The yield of culls (small sound tubers) was 16½ bu. per acre for the sprayed and 25½ bu. for the unsprayed. There was somewhat more rot on the unsprayed rows than on the sprayed, but not much in either case.

South test.—Here, also, eighteen rows were required to make an acre. The yields were as follows:

Two sprayed rows,[24] 2,167 lbs. marketable tubers.
Middle two unsprayed rows, 2,007 lbs. marketable tubers.
Yield, sprayed, 325 bu. 3 lbs. marketable tubers per acre.
Yield, unsprayed, 301 lbs. marketable tubers per acre.
Gain, 24 bu. marketable tubers per acre.

The yield of culls was 28 bu. 39 lbs. per acre for the sprayed and 23 bu. 51 lbs. per acre for the unsprayed. The conditions as regards rot were the same as in the north test.

[23] The second sprayed row on either side of the check.
[24] The second and third sprayed rows on the south side of the check.

Why the gain was so much greater in the north test is not known The conditions in the two tests were practically the same except that in the north test the check rows were accidentally sprayed on July 3; but this would tend to lower the gain in the north test. Fortunately, the spraying was a light one owing to the spray pump being out of order and the pressure low.

Combining the results obtained in the two tests we find that the average increase in yield due to spraying in this experiment was 49 bu. 12 lbs. per acre. At 50 cents per bushel, which was the market price at the time of digging the test rows, this increase would be worth $24.60. Deducting $6.84, the expense of spraying, there remains *a net profit of* $17.76 *per acre.* The actual selling price was 50 and 55 cents per bushel for about one-half the crop and 60 cents per bushel for the remainder.

SUMMARY OF BUSINESS EXPERIMENTS IN 1905.

The principal features of the fourteen business experiments are shown in the following table:

TABLE XI.—SHOWING RESULTS OF BUSINESS EXPERIMENTS.

EXPERIMENT.	Area sprayed.	No. of times sprayed.	Increase in yield per acre.	Total cost of spraying per acre.	Cost per acre for each spraying.	Net profit per acre.[25]
	A.		Bu.			
Gowanda	10	4	46 1/3	$3 76	$0 94	$23 93
Gainesville	16	7	67 1/6	5 41	77 1/3	22 63
Arkport	6	4	34 5/6	3 95	98 3/4	13 39
Atlanta	8	3 to 4	44 1/6	3 50	99 1/2	18 59
Spencerport	10	3	53 1/2	2 44	81 1/3	29 47
Verona Mills	11	5	49 1/2	5 02	1 00	27 01
Cassville	11	5	33 1/2	4 31	86	20 83
Cortland.[26]	6	5	173	6 50	1 30	....
Chateaugay	17	5 to 7	60 1/4	4 04	77	13 50
Peru	10	4	36 1/2	2 41	65 1/4	17 31
Hebron	6	2	39 3/4	4 02	2 01	11 64
Syosset	21	3	35 5/6	4 09	1 36 1/3	17 41
Mattituck	16 2/3	7 1/2	54 1/6	5 55	74	26 94
Bridgehampton	18	8	49 1/5	6 84	85 1/2	17 76

Total area sprayed in thirteen experiments, 160 2-3 acres.
Average increase in yield per acre, 46 1-2 bushels.
Average total cost of spraying per acre, $4.25.
Average cost per acre for each spraying, 98 cents.
Average net profit per acre, **$20.04.**

[25] Based on local market prices for potatoes at time of digging the test rows.
[26] In computing the averages following Table XI, the Cortland experiment has not been included. The gain in this experiment may not have been entirely due to spraying. See page 143.

SUMMARY OF BUSINESS EXPERIMENTS IN 1904.

Total area sprayed in fourteen experiments, 180 acres.
Average increase in yield per acre, 62 1-4 bushels.
Average total cost of spraying per acre, $ 4.98.
Average cost per acre for each spraying, 93 cents.
Average net profit per acre, **$24.86.**

SUMMARY OF BUSINESS EXPERIMENTS IN 1903.

Total area sprayed in six experiments, 61 1-6 acres.
Average increase in yield per acre, 57 bushels.
Average total cost of spraying per acre, $4.98.
Average cost per acre for each spraying, $1.07.
Average net profit per acre, **$23.47.**

Average net profit for three years, $22.79 per acre.

VOLUNTEER EXPERIMENTS.

In 1904 the Station began collecting and recording the results of experiments made by farmers in all parts of the State. As these experiments were carried out entirely by the farmers themselves we call them volunteer experiments. Forty-one such experiments made in 1904 were reported in Bulletin 264.

It was hoped that in 1905 a much larger number of volunteer experiments might be secured for publication in the present bulletin. In the spring many farmers were urged to make volunteer experiments and in the fall they were requested to report results. Although considerable effort was expended in this line only 50 reports were obtained. Evidently, our farmers are not experimenting as much as they should. We have had occasion to mention this before.

The highly favorable results obtained in the numerous experiments made by the Station and by New York farmers during the past four years should stimulate potato growers to give spraying a trial. If it really is as profitable as these experiments indicate they can not afford to neglect spraying. As a matter of fact many are beginning to practice spraying, but only a few are making any attempt to determine how much the yield is increased thereby or whether the spraying is profitable. Let us have more experiments in 1906. It is a very easy matter to make potato spraying experiments like the farmers' business experiments reported in this bulletin. The two important points to be determined are: (1) The increase in yield due to spraying; and (2) the expense of spraying.

To make a detailed report of each of the volunteer experiments as was done in Bulletin 264 necessitates frequent repetition of certain statements and requires an unnecessarily large amount of space in the bulletin. It is believed that these reports may be greatly condensed without materially reducing their value. The leading features of the 50 volunteer experiments are shown in the following table:

TABLE XII.—SHOWING RESULTS OF VOLUNTEER EXPERIMENTS IN 1905.

Experiment.	Location.	Name.	Area sprayed.	Times sprayed.	Yield per acre. Sprayed.		Yield per acre. Not sprayed.		Gain per acre due to spraying.		Cost per acre each spraying.	Price of potatoes.	Kind of sprayer.
			A.		Bu.	lbs.	Bu.	lbs.	Bu.	lbs.		Cts.	
1	Dewittville	G. A. Kirkland	6	6	215	37	140	37	75	—	$1 16	65	One-horse, home-made, 2-row.
2	Dunkirk	C. S. Aldrich	2	3	197	—	173	—	24	—	....	75	Knapsack.
3	Poland Center	Newel Cheney	3	11	188	41	152	29	36	12	70	60	One-horse, 4-row.
4	Springville	C. E. Safford	......	4	175	57	97	45	78	12	1 25	50	Knapsack.
5	Fillmore	O. C. Gibbs	8½	4	180	54	130	48	50	6	....	62	Two-horse, 5-row, home-made.
6	Pike	C. M. Dennis	12½	4	150	—	100	—	50	—	....	40–60	
7	Hardys	L. H. Taylor	10	5	184	41	128	29	56	12	70	50	One-horse, home-made, 4-row.
8	Castile	L. J. Wilson	10	5	204	35	155	56	48	39	62	40–60	Two-horse, home-made, 4-row.
9	Elba	C. W. Driggs	1½	3	153	49	135	29	18	20	77	60	4-row, horse sprayer.
10	Batavia	G. A. Prole	10½	6	181	48	118	43	63	5	67	52	Two-horse, home-made, 5-row.
11	W. Henrietta	C. M. Lyday	6	7	198	—	136	7	61	53	43½	50	Peppler 1-horse, 6-row power sprayer.
12	W. Henrietta	Wm. Robert	15	7	229	41	148	49	80	52	....	50	Brown power sprayer.
13	West Rush	D. S. Norris	5	5	257	18	166	—	91	18	70	42–45	Home-made, 4-row.
14	West Rush	T. E. Martin	17½	20	352	20	215	40	136	40	40	38	One-horse, home-made, 6-row, geared.
15	Andover	E. R. Crandall	5	4	100	—	55	—	45	—	....	50	One-horse, 4-row, power sprayer.
16	Nichols	Daniel Dean	14½	3	146	40	93	30	53	10	....	68–75	Watson, 4-row, 1-horse power sprayer.
17	Coopers Plains	W. L. McConnell	1	3	242	—	221	50	20	10	....	60	Knapsack.
18	Campbell	E. S. Cole	1	2	100	48	72	36	28	12	....	50	Hand sprayer.
19	Beaver Dams	A. J. Moore	5	3	165	—	144	—	21	—	1 16	60	Watson, one-horse, 4-row, power sprayer.
20	Victor	C. E. Green	10	8	230	—	166	34	63	26	....	60	Home-made, 4-row.
21	Canandaigua	H. Van Voorhis	14	4	191	9	119	28	71	41	1 00	50	Two-horse, 6-row, home-made, geared.

22	Clifton Springs	J. F. Curran	6 3/10	5	199	10	127	50	71	20	1 13	60	Aroostook, 6-row, 2 horse power sprayer.
23	Clifton Springs	P. H. Pettit	18	4	147	58	117	45	30	13	68	55	Brown, 4-row, 2-horse power sprayer.
24	Phelps	J. V. Salisbury & Sons	25	5	140	12	58	25	81	47	80	60	Aroostook, 2-horse, 6-row power sprayer.
25	Phelps	M. B. Newman	15	5	300	—	200	—	100	—	90	55	Aroostook, 2-horse, 6-row, power sprayer.
26	Geneva	H. W. Hadlow	1/3	3	194	41	176	31	18	10	2 03	50	Knapsack.
27	Ovid	J. M. Bennett	2	3	97	30	53	11	44	19	....	50–60	
28	Interlaken	M. C. Brokaw	10	5	230	—	145	—	85	—	....	40	One-horse, home-made, 2-row outfit.
29	Interlaken	F. C. & L. B. Bradley	5	6	187	46	105	46	82	—	1 02	50	Two-horse, home-made, 4-row outfit.
30	Trumansburg	F. N. Smith	20	10	252	—	144	—	108	—	50	60	Watson, 2-horse, 4-row power sprayer.
31	Jordan	F. O. Chamberlin	10	6	70	—	58	21	11	39	53	70	Home-made cart with barrel spray pump.
32	Fulton	V. W. Shattuck	6½	4	230	46	176	19	54	27	....	60	One-horse, home-made 4-row.
33	Clay	C. N. Breman	1¼	5	260	48	196	56	63	52	98	45–55	Home-made cart.
34	S. Onondaga	G. G. Hitchings	32	6	117	22	62	7	55	15	50	55	Niagara gas sprayer, 2-horse, 2-row.
35	Fayetteville	F. E. Dawley	5	5	220	30	156	30	64	—	98	60	Iron Age, one-horse, 4-row, power sprayer.
36	Schuyler Lake	D. C. Williams	2	4	286	46	145	12	141	34	1 32	60	Knapsack.
37	Constableville	C. H. Zimmer	1	3	326	—	256	—	70	—	....	50	Comp. air sprayer.
38	Constableville	G. P. Bernholz	1	3	237	58	159	19	78	39	1 58	50	Five-gallon, comp. air sprayer.
39	Malone	T. J. Shields	10	3	132	—	110	—	22	—	....	50	Aspinwall, 1-horse, 4-row power sprayer.
40	Ellenb'gh Depot	Wm. Brennan	10	3	247	30	38	30	209	—	....	40	Home-made cart, 4-rows.
41	Peru	John Mannix	6	4	158	12	112	—	46	12	75	51	5-gallon, compressed-air sprayer.
42	Westport	J. M. Graeff	5	2	224	—	192	—	32	—	....	75	Gould, 1-horse, 2-row automatic sprayer.
43	Greenfield Center	E. D. Harris	¼	1	121	—	111	—	10	—	....	45	Hand sprayer.
44	Saratoga Springs	John Gick	2	3	242	—	242	—	0	—	....	60	Common garden sprinkler.
45	Akin	J. T. Buchanan	7½	5	240	39	179	32	61	7	....	65	Aspinwall, 1-horse, 4-row, power sprayer.

TABLE XII.— SHOWING RESULTS OF VOLUNTEER EXPERIMENTS IN 1905 (*Concluded*).

EXPERIMENT.	Location.	Name.	Area sprayed.	Times sprayed.	YIELD PER ACRE. Sprayed.		YIELD PER ACRE. Not sprayed.		Gain per acre due to spraying.		Cost per acre each spraying.	Price of potatoes.	Kind of sprayer.
			A.		*Bu.*	*lbs.*	*Bu.*	*lbs.*	*Bu.*	*lbs.*		*Cts.*	
46.	W. Sand Lake	J. Jeannin, Jr.	½	2	157	56	114	38	43	18	$2 21	65	Auto compressed air sprayer.
47.	Setauket	W. S. Rowland	11	4	220	—	165	—	55	—	....	50–60	Aspinwall, 1-horse, 4 row power sprayer.
48.	Riverhead	D. H. Hudson	4	5	216	20	155	28	60	52	73	50	Hudson, 4-row power sprayer.
49.	Riverhead	E. Salmon	20	6	200	—	150	—	50	—	....	60	Peppler, 2-horse, 6-row power sprayer.
50.	Water Mill	C. B. Foster	12	10	251	—	196	50	54	10	81	50	One-horse, Shangle 6 to 7 rows.

SUMMARY OF THE VOLUNTEER EXPERIMENTS IN 1905.

Total area sprayed in 50 experiments, 407 acres.
Average increase in yield per acre, 59 bu. 32 lbs.
Average total cost of spraying per acre, (29 experiments), $4.57.
Average cost per acre, for each spraying (29 experiments), 92 cts.
Average market price of potatoes at digging time, 57 cts.
Average net profit per acre (29 experiments), $29.85.

SUMMARY OF THE VOLUNTEER EXPERIMENTS IN 1904.[27]

Total area sprayed in 41 experiments, 363 3/4 acres.
Average increase in yield per acre, 58 bu. 28 1/2 lbs.
Average total cost of spraying per acre (23 experiments) $3.91.
Average cost per acre for each spraying (23 experiments), 90 2/3 cents.
Average market price of potatoes at digging time, 43 1/2 cents per bushel.
Average profit per acre (23 experiments), $22.01.

REMARKS ON THE VOLUNTEER EXPERIMENTS IN 1905.

It is probable that the yields, expense of spraying and other data given for the volunteer experiments are not as accurate as are those given for the farmers' business experiments. The former have been furnished entirely by farmers, some of whom made the experiments merely for their own information and consequently were not as careful in measuring the yields as they would have been had they known that the figures were to be published. However, the increase in yield due to spraying has in all cases been determined by actual measurement or weight and not estimated. The yields given in Table XII refer to marketable tubers only, except in Experiments No. 8 and 21 as noted below. The expense of spraying includes both labor and chemicals and, in some cases, also an allowance for wear of sprayer.

Several of the experiments have interesting features which could not be shown in the table; hence they are brought together here.

Experiment No. 1.—The dates of spraying were July 3, 11, 22, August 4, 16 and 29. There was practically no loss from rot either on the sprayed or unsprayed rows. The difference in yield (75 bu. per acre) was due to the longer growth on the sprayed rows. "Spraying appeared to prolong the life of the vines about three

[27] Copied from Bulletin 264, page 187.

weeks." The items of expense for spraying six acres six times were as follows:

310 lbs. copper sulphate @ 5¾c.	$17.82
32 " paris green @ 15½c.	4.96
Freight on copper sulphate and paris green	.52
Lime	1.40
78 hrs. labor for man @ 12½c.	9.75
58 " labor for horse @ 10c.	5.80
Wear on sprayer (10 per cent. of cost)	1.60
Total	$41.85

Experiment No. 2.—Report obtained through the courtesy of Prof. J. L. Stone of the Cornell University Experiment Station. The potatoes in this experiment were planted very late—July 3 and 5—following a crop of peas grown for the canning factory.

Experiment No. 3.—The test rows were dug and measured in the presence of Prof. J. L. Stone through whose courtesy we are able to publish the retsults. The potatoes were sprayed six times, but in five of these times the plants were gone over twice so that in reality the number of sprayings was eleven. At digging time the sprayed rows showed rot to the amount of 24 bu. 10 lbs. per acre while on the unsprayed rows it was only 6 bu. 56 lbs. per acre. Concerning this, Prof. Stone writes as follows: "As Mr. Cheney states, it seemed that there were fewer diseased potatoes in the unsprayed area because the decay had gone on so repidly that most of the diseased potatoes had disappeared or at least remained only as shriveled skins." Mr. Cheney has made a practice of spraying his potatoes during the past twelve years.

Experiment No. 4.—Spraying reduced the loss from rot.

Experiment No. 5.—The dates of spraying were July 10, 17, August 5 and 19. Bordeaux of the 6-6-50 formula was applied at the rate of 50 gallons per acre in the first three sprayings and 75 gallons per acre in the last one. Paris green at the rate of one pound per acre was applied with the bordeaux in the first two sprayings. On the same dates the unsprayed rows were treated with paris green in water. The unsprayed rows were free from rotten tubers while on the sprayed rows the loss from rot was at the rate of 25 bushels per acre.

Experiment No. 6.—Used one nozzle per row in the first two sprayings and two nozzles per row in the last two. The unsprayed rows died three weeks earlier than the sprayed ones.

Experiment No. 7.—The sprayed rows outlived the unsprayed ones from two to three weeks. There were quite a good many more rotten tubers on the sprayed rows. The expense of spraying ten acres five times was $21 for materials and $14 for labor (man and team four days) making a total of $35.

Experiment No. 8.—The sprayed rows lived ten days longer than the unsprayed ones. The expense of spraying ten acres five times was $13.40 for lime and blue vitrol and $17.50 for labor (man and team five days) making a total of $30.90. The yields given in the table are for unsorted potatoes.

Experiment No. 9.—The dates of spraying were August 25 and September 2 but as the spraying of August 25 was a double one it seems proper to consider that the plants were sprayed three times. The items of expense for spraying one and one-half acres three times were as follows:

25 lbs. copper sulphate @ 5½c	$1.38
32 " "new process" lime @ 1c	.32
6 hrs. labor for man @ 15c	.90
3¼ " labor for team @ 15c	.49
Use of sprayer	.40
Total	$3.49

Experiment No. 10.—The bordeaux was applied at the rate of 30 gallons per acre at each spraying, but Mr. Prole expresses the opinion that a larger quantity would have given better results. Another season he will go over the rows in both directions at each spraying, using about 60 gallons per acre.

Experiment No. 11.—The dates of spraying were July 8, 14, 21, August 1, 8, 17 and 28. In the first and last sprayings the bordeaux used was of the 5-5-50 formula; in the others it was 4-4-50. It was applied at the rate of 33 gallons per acre each time. Mr. Lyday thinks one additional spraying would have increased the yield still further.

Experiment No. 12.—Seven sprayings were made between July 10 and September 2. Three unsprayed rows 48 rods long yielded

23 bushels, while three sprayed rows on one side yielded 35 bushels and three on the other 36 bushels. Mr. Roberts believes that the early sprayings are the most important.

Experiment No. 13.—In addition to five applications of bordeaux the plants were treated twice with paris green. The sprayed rows outlived the unsprayed ones by three weeks.

Experiment No. 14.—Ten double sprayings (=20 single sprayings) were made between June 30 and September 7. The total quantity of bordeaux used on 17½ acres was 12,980 gallons which is at the rate of 742 gallons per acre. Check rows were left in three different lots. In Lot No. 1 the gain due to spraying was 120 bushels per acre; in Lot No. 2 it was 192 bushels per acre; and in Lot No. 3, 98 bushels per acre. The average gain was 136⅔ bushels per acre. The total yield on 18 acres (17½ a. sprayed and ½ a. unsprayed) was 4,825 bushels which is at the rate of 268 bushels per acre.

Experiment No. 15.—Most of the field on both sides of the four unsprayed rows was sprayed four times and gave an average yield of 100 bushels per acre; but some rows at one side of the field were sprayed seven times. These rows yielded at the rate of 123 bushels per acre.

Experiment No. 16.—The total yield on 14½ acres was 2,100 bushels which is at the rate of 145 bushels per acre. This shows that the test rows were located in a representative portion of the field.

Experiment No. 17.—The unsprayed rows died two weeks earlier than the sprayed ones. Spraying reduced the loss from rot.

Experiment No. 18.—On the unsprayed rows the loss from rot was at the rate of 38⅓ bushels per acre, while on the sprayed rows it was 28¼ bushels per acre.

Experiment No. 19.—The loss from rot was the same on sprayed and unsprayed rows; viz., 21 bushels per acre. This field of five acres was the only one in the vicinity of Beaver Dams which was sprayed in 1905.

Experiment No. 20.—The test rows were dug and weighed in the presence of a Station representative.

Experiment No. 21.—The yields given are for unsorted potatoes.

Experiment No. 22.—In this experiment the net profit from spraying was at the rate of $37 per acre. Mr. E. Haggerty of Clifton Springs witnessed the digging and weighing of the test rows. The loss from rot was at the rate of 4 bu. 33 lbs. per acre on the sprayed rows and 4 bu. 16 lbs. on the unsprayed rows.

Experiment No. 23.—The test rows were much injured by excessive rain in late spring. No rot.

Experiment No. 24.—The unsprayed rows were "dead several weeks before the sprayed ones." No rot.

Experiment No. 25.—The unsprayed rows were dead within two weeks after the first appearance of blight.

Experiment No. 26.—The unsprayed row was only slightly injured by blight.

Experiment No. 27.—The loss from rot was 17¾ bu. per acre on the sprayed rows and 24 1-6 bushels on the unsprayed rows. Mr. Bennett thinks that more thorough spraying would have given better results.

Experiment No. 28.—A part of the ten acres was sprayed five times, a part three times and the remainder only twice. The yields given in the table are for test rows located in the portion of the field sprayed five times.

Experiment No. 29.—There were only four applications, but in the last two applications the plants were gone over twice each time. Hence, the number of sprayings is given as six. The unsprayed rows were severely injured by flea beetles and slightly also by bugs. There was a marked difference in the amount of rot. On the unsprayed rows the loss from rot was 34⅗ bu. per acre, while on two sprayed rows 50 rods long there were but nine rotten tubers.

Experiment No. 30.—Report obtained through the courtesy of Prof. J. L. Stone. Five double sprayings (= 10 single sprayings) were made. The total yield of 20 acres was 5,383 bushels, which is at the rate of 269 bu. per acre. At digging time the market price of potatoes in Ithaca was 60 cents per bushel, but the crop was sold later at 70 cents per bushel. The actual net profit from spraying in this experiment was $70 per acre.

Experiment No. 31.—At digging time the yield of sprayed and unsprayed rows was measured but not recorded. The yields given in the table are estimates. However, Mr. Chamberlin remembers

distinctly that the difference between sprayed and unsprayed rows was just one bushel on two rows 34 rods long which is at the rate of 11⅔ bushels per acre. Excessively wet weather is largely responsible for the small yields.

Experiment No. 32.—One row near the center of the field was left unsprayed. The gain due to spraying amounted to one bushel per hundred hills or 54 bu. 27 lbs. per acre. The total yield on 6½ acres was 1,500 bushels which is at the rate of 230 bu. 46 lbs. per acre.

Experiment No. 33.—The bordeaux was applied five times at the rate of 60 gallons per acre. The expense of spraying includes only labor and chemicals. No allowance is made for wear of sprayer.

Experiment No. 34.—Unsprayed rows were left in each of three varieties. On the variety Carman the gain due to spraying was 63 bushels per acre; on Mammoth Whiton, 34½ bushels; and on Rural New Yorker No. 2, 68⅓ bushels, making an average gain of 55¼ bushels per acre.

Experiment No. 35.—The percentage of rot was very much lessened by spraying.

Experiment No. 36.—One half acre was sprayed four times, ½ acre twice, one acre once and ½ acre left unsprayed. The half acre sprayed four times yielded 143 bu. 23 lbs. or at the rate of 286 bu. 46 lbs. per acre; while the unsprayed half acre yielded only 72 bu. 36 lbs. or at the rate of 145 bu. 12 lbs. per acre. On the unsprayed half-acre the loss from rot was heavy; on the sprayed half-acre much less.

Experiment No. 37.—The loss from rot was at the rate of one bushel per acre on the sprayed rows and 29 bushels per acre on the unsprayed ones.

Experiment No. 38.—There was apparently but little blight, yet there was some rot both on sprayed and unsprayed rows.

Experiment No. 39.—The sprayed rows outlived the unsprayed ones about 12 days. On sprayed rows the loss from rot was about 11 bu. per acre and on the unsprayed ones 22 bu. per acre.

Experiment No. 40.—In this experiment the enormous gain was mostly due to the prevention of rot. About three-fourths of the unsprayed potatoes rotted while there was only a little rot among the sprayed ones.

Experiment No. 41.—The unsprayed rows died two weeks earlier than the sprayed ones.

Experiment No. 42.—The potatoes were sprayed twice with bordeaux and paris green and treated once besides with paris green in water. Mr. Graeff states that three applications of paris green for bugs would have been required anyway so that the extra expense of spraying for blight was only the cost of materials. "There was no noticeable difference as to rot between the sprayed and unsprayed."

Experiment No. 43.—The sprayed rows were killed by frost about a week after the unsprayed rows died from blight.

Experiment No. 44.—The unsprayed rows were not affected by blight.

Experiment No. 45.—The gain due to spraying is based on the difference in yield between an unsprayed row and a sprayed one fifteen feet distant. Mr. Buchanan estimates that where he sprayed at least one-fifth of the crop rotted and on unsprayed rows the loss was still greater.

Experiment No. 46.—Very little blight and no rot in this experiment.

Experiment No. 47.—The sprayed rows lived two weeks longer than the unsprayed ones. The total yield of 11 acres was 2,247 bushels which is at the rate of 204 bushels per acre.

Experiment No. 48.—In this experiment the expense of spraying includes the cost of water which was purchased at three cents per barrel. The spraying consisted of three single applications and one double one or five in all.

Experiment No. 49.—A portion of the field was sprayed only five times. Spraying lessened the amount of rot.

Experiment No. 50.—The items of expense for spraying 12 acres ten times were as follows:

625 lbs. copper sulphate @ 6c	$37.50
3 bbl. lime @ $1.75	5.25
49 hrs. labor for two men @ 20c.	19.60
24 " labor for single horse @ 10c	2.40
25 " labor for team @ 20c.	5.00
46 lbs. paris green @ 16½c	7.59
27 " paris green @ 17½c	4.73
Wear on sprayer	15.00
Total	$97.07

The test rows were in a two-acre field which was dug after the vines were dead, but before the time when potatoes rotted badly. In this field there was practically no rot on either the sprayed or unsprayed rows. The remaining ten acres were dug later, after the rot epidemic, and the loss from rot was estimated at 40 to 50 bushels per acre. As unsprayed fields in the same vicinity did not rot to any extent Mr. Foster believes that his actual gain from spraying was not as great as the yield of the test rows indicate. For further discussion of this experiment see page 185.

The writers take this opportunity to heartily thank the gentlemen who have furnished the reports of their volunteer experiments for publication. Potato growers throughout the State are under obligations to them.

SODA BORDEAUX VS. LIME BORDEAUX.

It has been stated that soda bordeaux is superior to lime bordeaux for spraying potatoes, but experiments of the past two years show that this is probably not true. In an experiment made by this Station in 1904 lime bordeaux gave better results by 16⅔ bushels per acre.[28] Another experiment in 1905 resulted in a difference of nine bushels per acre in favor of lime bordeaux. The latter experiment included fifteen rows each 290½ feet long. Five were sprayed four times with soda bordeaux (made with six pounds of copper sulphate and seven and one-half pounds of sal soda to 50 gallons), five with lime bordeaux (6-4-50 formula) and the other five were not sprayed. The sprayed and unsprayed rows alternated as in the ten-year experiment. The spraying was done with a knapsack sprayer and very thoroughly by going over each row twice—out on one side and back on the other. The dates of spraying were June 30, July 10, August 1 and 2, and August 23. In the first three sprayings paris green was used with both kinds of bordeaux and on the same dates the unsprayed or check rows were treated with the same quantity of paris green in lime water.[29]

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[28] For details of this experiment see Bulletin 264, pages 187-194.

[29] Ten ounces of paris green to 50 gallons in the first spraying and one pound to 50 gallons in the second and third sprayings.

TABLE XIII.—YIELDS IN THE SODA BORDEAUX EXPERIMENT.

Rows	Treatment.	Yield per row.		Yield per acre.			
		Marketable.	Small.	Marketable.		Small.	
		Lbs.	Lbs.	Bu.	lbs.	Bu.	lbs.
1...	Unsprayed	106	43	88	20	35	50
2...	Lime bordeaux	233	43	194	10	35	50
3...	Soda bordeaux	244	37	203	20	30	50
4...	Unsprayed	111	49	92	30	40	50
5...	Lime bordeaux	224	24	186	40	20	—
6...	Soda bordeaux	235	38	195	50	31	40
7...	Unsprayed	86	29	71	40	24	10
8...	Lime bordeaux	214	26	178	20	21	40
9...	Soda bordeaux	217	28	180	50	23	20
10...	Unsprayed	79	38	65	50	31	40
11...	Lime bordeaux	265	33	220	50	27	30
12...	Soda bordeaux	226	42	188	20	35	—
13...	Unsprayed	109	37	90	50	22	30
14...	Lime bordeaux	277	26	230	50	21	40
15...	Soda bordeaux	235	23	195	50	19	10

The potatoes were dug October 23 and sorted into two grades—sound tubers of marketable size and sound tubers below marketable size. No account was taken of rotten tubers. The yields are shown in Table XIII.

In each of the first three sections of the experiment the soda bordeaux gave slightly better results, while in the last two sections lime bordeaux was considerably in the lead so that on the average there was a difference of 9 bu. 20 lbs. of marketable tubers per acre in favor of the lime bordeaux. The average yields for the three kinds of treatment were as follows:

Sprayed with lime bordeaux, 202 bu. 10 lbs. marketable tubers per acre.
Sprayed with soda bordeaux, 192 bu. 50 lbs. marketable tubers per acre.
Unsprayed, 81 bu. 50 lbs. marketable tubers per acre.

The rows sprayed with lime bordeaux outyielded the unsprayed rows by 120⅓ bushels per acre. The unsprayed rows died early from blight and bugs. Although the unsprayed rows received the same amount of paris green as did the sprayed rows and it was applied on the same dates and with equal thoroughness, they were, nevertheless, much more severely injured by bugs than were the sprayed rows. This is only another example of the well known fact that bordeaux assists in the control of bugs.

No attempt was made to determine accurately the loss from rot in this experiment. It seems to be about the same as in the ten-year experiment. (See page 128). In this respect there was appar-

ently no difference between the rows sprayed with lime bordeaux and those sprayed with soda bordeaux.

Further experimental evidence on the relative value of these two kinds of bordeaux for potatoes is furnished by an experiment made by F. A. Sirrine at Riverhead, Long Island, in 1905. A plat of potatoes containing eight rows 235 feet long and sprayed four times with lime bordeaux yielded at the rate of 211 bushels per acre, while another plat of eight rows similarly sprayed with soda bordeaux yielded only 176 bushels per acre, making a difference of 35 bushels per acre in favor of the lime bordeaux. The two plats were only two rows apart.

Certainly, the results of these experiments are not favorable to soda bordeaux. The most that can be said for soda bordeaux is that it is probably about equal to lime bordeaux in efficiency and that its mechanical condition is slightly better. Poisons can not be used as safely with it as with lime bordeaux. We advise the use of lime bordeaux.

BORDEAUX WITH PARIS GREEN VS. BORDEAUX ALONE.

The Station made an experiment on this in 1904. There was no injury to the foliage and the yield was in favor of bordeaux with paris green by 7½ bushels per acre.[30] Another experiment was made in 1905. Again there was no injury to the foliage and the yield was in favor of bordeaux with paris green by five bushels per acre. In the latter experiment there were 15 rows 86 feet long. Five rows were sprayed five times with bordeaux and paris green (one pound to fifty gallons), five with bordeaux only and the other five (checks) with paris green in lime water (one pound to fifty gallons). The rows of the different treatments alternated with each other as in the ten-year experiment. The spraying was done with a knapsack sprayer very thoroughly and as uniformly as possible. The quantity of bourdeaux used varied from 100 to 300 gallons per acre in different sprayings according to the size of the plants. In order to make sure that the bordeaux used was the same in both cases the following method was employed in each spraying: A

[30] Details of this experiment given in Bulletin 267, pp. 269-278.

quantity of bordeaux was prepared. A part of this was used for spraying the rows which were to receive bordeaux only; then paris green was added to the remainder and the rows which were to receive bordeaux with paris green were sprayed The dates of spraying were June 29, July 6, July 20, August 7 and August 21.

At the beginning of the experiment it was the intention to keep the bordeaux-only rows free from bugs by hand picking as in the experiment in 1904; but after one picking it was found that this could be much more easily accomplished by very thorough spraying with bordeaux just after the bugs were hatched. In this manner the bugs were kept entirely under control so that they were eliminated from the experiment.[31]

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[31] In this experiment and also in the experiment with arsenite of soda, page 179 it was shown that bugs may be controlled with bordeaux mixture alone provided the spraying is done just after the bugs have hatched and very thoroughly. But for this fact this experiment could not have been carried through properly. After the first spraying of June 29 a few bugs remained alive and these were removed by hand picking July 3. On July 5, we were dismayed to find all of the plants swarming with young bugs. Of course it was to be expected that on the rows treated with paris green they would be poisoned before they could do harm; but on the rows sprayed with bordeaux alone they would surely injure the plants and thereby ruin the experiment. For the most part, the bugs were located among the small young leaves in the tops of new shoots. To have removed them by hand picking would have been a tedious operation, besides it could not well have been accomplished without considerable mutilation of the plants. In this emergency we decided to try bordeaux mixture. Accordingly, the second spraying was made July 6, or about a week earlier than it would have been made had not this trouble with bugs arisen. The operator was instructed to give special attention to the new growth and to spray very thoroughly. Twenty-four hours after the spraying most of the bugs had disappeared on the "bordeaux-only" rows as well as on those on which poison had been used. The bugs still in evidence appeared uneasy. Some were traveling on the ground under the plants. Practically all of them disappeared so that no harm was done to the plants and no further hand picking or other treatment for bugs was necessary. Whether the bugs were actually killed by the bordeaux could not be determined, but they certainly disappeared.

Although this experiment was entirely successful we do not believe that farmers should attempt to control bugs by the use of bordeaux alone. The method is too expensive and requires too much care. To be successful the spraying must be done with extreme thoroughness and while the bugs are very small. Nevertheless the results have a direct bearing on practical potato spraying. They show that the bordeaux is not only a preventive of blight, but also an aid in the control of bugs and should be used with the poison whenever it is necessary to combat bugs.

Throughout the season there was no apparent difference in the appearance of the foliage on the rows sprayed with bordeaux only and that on the rows sprayed with bordeaux and paris green. There was no indication that the paris green in the bordeaux was injurious to the foliage. The check rows receiving paris green in lime water blighted considerably and died somewhat prematurely, but there was no evidence that the foliage was injured by paris green.

The potatoes in this experiment were dug by hand October 26. The yields are shown in the following table:

TABLE XIV.—SHOWING YIELDS IN PARIS GREEN EXPERIMENT.

TREATMENT.	ROWS.	YIELD OF FIVE ROWS.		YIELD PER ACRE.			
		Marketable.	Small.	Marketable.		Small	
		Lbs.	*Lbs.*	*Bu.*	*lbs.*	*Bu.*	*lbs.*
Bordeaux with paris green..	1, 2, 7, 10, 13.	579	34	325	53	19	8
Bordeaux only............	2, 5, 8, 11, 14.	570	37	320	49	20	49
Paris green in lime water...	3, 6, 9, 12, 15.	378	44	212	45	24	45

Difference in favor of bordeaux with paris green, 5 bu. 4 lbs. per acre.

The results of these experiments agree with the experience of potato growers who practice spraying. During the past four years the writers have been close observers of potato spraying and have seen no evidence that potatoes are in any way injured by paris green properly applied; viz., in moderate amount (one to two pounds per acre) with bordeaux mixture.

In a former experiment it was shown that paris green has some value as a preventive of potato blight.[32] With this fact in mind some potato growers have raised the question as to the advisability of using paris green with the bordeaux regularly. Our opinion is that it would not be profitable. Paris green should be added only when there are bugs or flea beetles to poison.

[32] See Bulletin 267 of this Station, page 272.

BORDEAUX WITH ARSENITE OF SODA VS. BORDEAUX ALONE.

In an experiment made at this Station in 1904 potato rows sprayed with bordeaux mixture containing arsenite of soda as poison yielded 34 bushels per acre less than rows sprayed with bordeaux mixture alone.[33] As there was no apparent injury to the foliage this reduction in yield was attributed to unequal conditions in the experiment rather than to the arsenite. However, it was deemed advisable to make the following experiment in 1905:

In a plat of 58 rows 108 feet long every other row was sprayed five times with bordeaux and arsenite of soda (one quart of stock solution[34] to 50 gallons), while the alternating 29 rows were sprayed with bordeaux only. As in the paris green experiment, care was taken to have the bordeaux of uniform character and uniformly applied. (At the rate of 100 to 300 gallons per acre in the different sprayings.) The bordeaux was made by the 1-to-8⅓ formula with lime in moderate excess of the quantity required to satisfy the potassium ferro-cyanide test. The frequent and thorough spraying kept the bugs so well under control that but one hand picking was required even on the bordeaux-only rows.[35] About July 20 all of the rows were slightly injured by bugs, but so far as could be determined there was no more damage to the bordeaux-only rows than to those receiving the arsenite. The dates of spraying were July 1, 6-7, 20, August 4-5 and 21-22.

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[33] Reported in Bulletin 267, pages 278-284.

[34] Prepared by the Kedzie formula as follows:—

White arsenic	pounds 2
Sal soda	pounds 8
Water	gallons 2

Boil until the arsenic is all dissolved which will take about 15 minutes.

[35] The second spraying made July 6 and 7 was entirely successful in destroying swarms of young bugs as in the paris green experiment (See footnote No. 31 on page 177. Even on the bordeaux-only rows, so few bugs survived that it was thought unnecessary to remove them by hand picking. However, by July 18 quite a good many bugs were in evidence, many of them being half-grown slugs. Having in mind our previous success we had little doubt that the bugs could be managed by spraying. By accident, the first rows which should have been sprayed with bordeaux and arsenite were sprayed with bordeaux only. This error made it necessary to spray the

At no time during the season did the difference in treatment seem to have any effect on the foliage. The yields were as follows:

TABLE XV.—SHOWING YIELDS IN THE ARSENITE OF SODA EXPERIMENT.

TREATMENT.	YIELD OF 29 ROWS.		YIELD PER ACRE.			
	Marketable.	Small.	Marketable.		Small.	
	Lbs.	*Lbs.*	*Bu.*	*lbs.*	*Bu.*	*lbs.*
Bordeaux with arsenite of soda......	2,928	297	226	14	22	57
Bordeaux only.....................	2,808	254	216	58	19	37

Difference in favor of bordeaux with arsenite of soda, 9 bu. 16 lbs. marketable tubers per acre.

We believe the results of this experiment to be trustworthy. They indicate that the arsenite of soda may be used safely with bordeaux at the rate of one quart of the stock solution (Kedzie formula) to fifty gallons. Probably considerably larger proportions of the arsenite would not be harmful. Arsenite of soda is a cheaper poison than paris green and remains in suspension better. Based on the arsenic it contains one quart of arsenite-of-soda stock solution is equivalent, in poisoning properties, to eight ounces of paris green.

DOES BORDEAUX MADE WITH COLD WATER INJURE POTATO FOLIAGE?

In making bordeaux for potatoes is it safe to use very cold water such as comes from deep wells? Will the foliage be injured? Such questions as these are asked occasionally. Some potato growers hold that spraying potatoes with very cold bordeaux on a hot, sunny day causes injury to the foliage. They advise that water from deep wells be allowed to stand in the air and warm before it is used for spraying potatoes.

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entire experiment with bordeaux alone. Only the younger bugs disappeared. The half-grown slugs continued their depredations. Accordingly, on July 20 the spraying was repeated and this time done properly. At the same time the bugs on the bordeaux-only rows were hand picked and there was no further trouble. This experience leads to the conclusion that while newly-hatched bugs may be successfully fought by thorough spraying with bordeaux alone, half-grown slugs can not be controlled in that way. Even when poisons are used bugs are much more easily killed while they are small.

In order to secure definite information on this point the following experiment was made on the Station grounds in 1905: Six rows of potatoes, 290½ feet long and of the variety Rural New Yorker No. 2 were planted especially for the experiment. Rows 1, 3 and 5 were sprayed three times with cold bordeaux, while Rows 2, 4 and 6 were sprayed on the same dates with warm bordeaux about the temperature of the air. The spraying was done with a knapsack sprayer and very thoroughly. The temperature was obtained immediately before spraying commenced by thrusting a thermometer into the knapsack after it was in position on the back of the operator. Two knapsackfuls were required to spray three rows and in the case of the cold bordeaux it was difficult to get the same temperature in both. This explains why two temperatures are given in the "cold bordeaux" column of the table below. The low temperatures were obtained by the use of cracked ice. The following table shows in condensed form the conditions under which the experiment was made:

TABLE XVI.—CONDITIONS IN THE EXPERIMENT OF COLD VS. WARM BORDEAUX.

DATE OF SPRAYING.	Temperature of cold bordeaux.	Temperature of warm bordeaux.	Temperature of the air.	Cloudiness.
	Deg. Fahr.	*Deg. Fahr.*	*Deg. Fahr.*	
June 30	50 to 54	74	70	Clear
July 12	50 to 54	81	88	Clear
August 8	40 to 42	70	82	Clear

At no time during the experiment was there any evidence that the cold bordeaux had injured the foliage and when the potatoes were dug it was found that the rows sprayed with cold bordeaux outyielded those sprayed with warm bordeaux at the rate of 4½ bushels per acre. This difference in yield may have been due to other causes than the difference in temperature of the bordeaux used, but being in favor of the cold bordeaux it removes all doubt as to the injurious effect of cold bordeaux. The results of this experiment seem to justify the opinion that no attention need be paid to the temperature of the water used in making bordeaux for spraying potatoes.[36]

[36] This statement applies only to the effect on the foliage. In this experiment no special attempt was made to determine the effect of the temperature

POTATO TROUBLES IN NEW YORK IN 1905.

Over the greater part of the State the season of 1905 was characterized by heavy losses from blight and rot. Throughout the growing season there was an abundance of rain in most localities. Floods in June caused much damage to potatoes on low ground and heavy rains in the latter part of September and fore part of October brought about an epidemic of potato rot. Many potato fields were killed by frost on September 14 and the remainder on September 26. Had it not been for the early frost several of the experiments reported in this bulletin would have shown considerably larger gains due to spraying.

Late blight, *Phytophthora infestans,* was destructive in nearly all parts of the State. The earliest outbreak of this disease of which we have definite knowledge occurred in the vicinity of Sagaponack and Wainscott in the eastern part of Long Island. Here, one of the writers found it already well established on July 1 and Mr. J. S. Strong, a farmer of Wainscott, states that he observed it as early as June 25. On July 2 it was found near Riverhead and on July 5 at Mattituck. It is reported to have appeared in a garden at Phelps about July 20, but the first specimens seen by us (excepting those from Long Island) came from Hornell where they were collected July 28. On August 1 we found it on early potatoes at Atlanta, Steuben County. Although carefully sought, no trace of late blight was found at Geneva until August 12.

Early potatoes were not affected with rot, but the late varieties suffered severely. In the Hudson Valley there was less loss from rot and blight than in any other part of the State. This region suffered from drought in July as did also Long Island.

The record for early blight, *Alternaria solani,* and flea beetles is about the same as in 1904. Early blight was rarely destructive except on Long Island where it was an important factor in many

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of the water on the mechanical condition of the bordeaux. However, it was observed that forty-degree bordeaux prepared by mixing copper sulphate solution having a temperature somewhat below 40 degrees Fahr. with milk of lime also below 40 degrees had apparently as good mechanical condition as had bordeaux made with the component solution at about 70 degrees Fahr.

fields. Flea beetles appeared in injurious numbers at several different points in the State, but were especially numerous and destructive on Long Island during the last ten days in July.

Colorado potato beetles or "bugs" were unusually troublesome. In many fields the plants were stripped of their foliage in spite of efforts made to control them. In some localities the demand for paris green exceeded the available supply with the result that local prices were materially advanced.

Judging from the results of numerous experiments the loss from blights, rot and flea beetles in unsprayed fields could not have been less than fifty bushels per acre on the average. In the 13 farmers' business experiments the average gain due to spraying was 46½ bushels per acre, while 50 volunteer experimenters reported gains averaging 59½ bushels per acre; and it should be borne in mind that these figures represent only a part of the damage done by blight and rot, because in only a few of the experiments was either the blight or the rot completely controlled.

DOES SPRAYING PREVENT ROT?

It is generally stated that spraying will prevent that rot of the tubers which often follows an attack of late blight, *Phytophthora infestans*. The theory advanced is, that spraying prevents the growth of the blight fungus on the leaves so that there are no spores, or at least *fewer* spores, to fall upon the ground and cause rot; hence there should be less rot where the plants have been sprayed.

As a matter of fact there are on record numerous experiments in which it was shown conclusively that the loss from rot was greatly reduced by spraying. Probably the most notable example is an experiment made by Jones and Morse[37] at the Vermont Station in 1904 in which unsprayed potatoes rotted at the rate of 245 bushels per acre while among sprayed potatoes under conditions otherwise parallel the loss from rot was only 27 bushels per acre.

However, there are also on record instances in which spraying had no appreciable effect in reducing the amount of rot; and it

[37] Jones, L. R. & Morse, W. J. Vt. Agr. Exp. Sta. Rep. 17: 389, 390.

has been the custom to explain such cases by assuming that the rot in question was not the late blight rot, but the dry rot (*Fusarium oxysporum*) or the bacterial wet rot (*Bacillus solanacearum*), two diseases which work only below ground and hence are not preventable by spraying.

At various times during the past four years this matter has been brought to our attention by farmers who complained that they had failed to prevent rot by spraying and some of them even claimed that spraying encourages rot. Accordingly, we took advantage of the excellent opportunity afforded by the rot epidemic of 1905 to make some observations along this line. The result is that our views on the subject have changed somewhat. Briefly stated our conclusion is as follows: The general tendency of spraying is to reduce the amount of rot. In most cases the reduction is very marked; in some cases there is no difference and occasionally spraying increases the amount of rot. It depends on weather conditions and the thoroughness of spraying. But whatever the effect on rot, *sprayed plants invariably give a larger yield of marketable tubers.*

It must be admitted that under certain conditions spraying increases rather than diminishes the amount of rot. For specific instances see the Cortland experiment, p. 141, the Cassville experiment, p. 143, and Volunteer Experiments Nos. 5 and 7, page 168. The explanation seems to be as follows: Rot is brought about chiefly by spores which fall from the blighted leaves to the ground and are carried by rain down through the soil to the tubers. These spores are delicate and readily killed by drying. Unsprayed plants may die prematurely from blight with scarcely any rot of the tubers provided the soil remains fairly dry until after the plants are dead and dry; because under such conditions the spores dry up and die before they can reach the tubers. No matter how much rain comes later there can be no rot because there are no live blight spores to cause rot. Now, suppose these plants had been sprayed in the manner in which spraying is usually done by farmers. Their life would have been prolonged two or three weeks. Nevertheless, they would have been somewhat affected by blight because farmers rarely spray thoroughly enough to prevent blight completely when the disease is epidemic; and so long as the plants remain green live blight spores continue to be formed on the leaves and fall upon the ground.

Then, if heavy rains came there would be rot. In short, spraying prolongs the period during which the tubers are subject to rot.

Sometimes there may appear to be more rot on sprayed rows than on unsprayed ones when in reality such is not the case. This happens when rot sets in early on unsprayed rows so that by digging time many of the tubers have completely decayed and disappeared; while on the sprayed rows where blight was unable to gain a foothold until late in the season and the rot correspondingly retarded, all affected tubers are still in evidence at digging time. For an example see Volunteer Experiment No. 3, p. 168; also Bulletin 264, pages 111–112.

When sprayed potatoes rot badly it should not be assumed, without investigation, that the spraying has been a failure. If any unsprayed rows have been left for comparison it will be found generally that they have rotted much worse so that in spite of the rot there may be enough more marketable potatoes on the sprayed rows to make the spraying a profitable operation. The Peru experiment on page 150 furnishes a good illustration. In Volunteer Experiment No. 50 made by C. B. Foster, Water Mill (page 173), there were, unfortunately, no check rows in the ten-acre field where the rot was so severe. Hence, it can not be determined whether the spraying was beneficial or otherwise; but judging from similar cases in which the facts are known we feel confident that the spraying was profitable notwithstanding the rot.

During the past season many cases were reported in which there was considerable loss from rot although there had been apparently little or no blighting of the vines. The explanation of this is that shortly before digging time the weather conditions were exceptionally favorable to rot so that a little blight, which may have passed unnoticed, was sufficient to cause much trouble. There may be much blight and yet little rot if the weather is dry for two or three weeks preceding digging, but if there is much rain during this period heavy loss from rot may follow a light attack of blight.

Concerning the identity of the rot which was so destructive in this State in 1905, we have no reason for believing that it was any other than the rot which follows late blight; namely, that caused by *Phytophthora infestans*. Other kinds of rot undoubtedly occurred, in small amount, but by far the greater part of the rot in New York

during the past season was certainly due to *Phytophthora infestans* and might have been largely prevented by thorough spraying. In this connection we wish to emphasize the importance of more thorough spraying in the latter part of the season as a safeguard against rot.

MAKING EXPERIMENTS IN 1906.

During the season of 1906 the work on potato spraying will be carried forward along practically the same lines as in 1904 and 1905. The regular ten-year experiments at Geneva and Riverhead will be conducted again as usual; also, about fifteen farmers' business experiments in different parts of the State. In addition the Station hopes to secure again, as in the past, reports of numerous volunteer experiments — the more the better. Potato growers throughout the State are earnestly requested to make spraying experiments in 1906 and report the results to the Station. Whatever the outcome of the experiments, whether for or against spraying, the reports are desired provided, of course, the experiments have been properly conducted. Upon request, the Station will supply blanks for making such reports.

DIRECTIONS FOR SPRAYING.[38]

In general, commence spraying when the plants are six to eight inches high and repeat the treatment at intervals of 10 to 14 days in order to keep the plants well covered with bordeaux throughout the season. During epidemics of blight it may be necessary to spray as often as once a week. Usually six applications will be required. The bordeaux should contain six pounds of copper sulphate to each 50 gallons.[39]. Whenever bugs or flea beetles are plentiful add one to two pounds of paris green or two quarts of arsenite of soda stock solution (See footnote, p. 179) to the quantity of bordeaux required to spray an acre.

Thoroughness of application is to be desired at all times, but is especially important when flea beetles are numerous or the

[38] Substantially the same as given in Bulletin 264, p. 204. The experiences of the past season do not warrant any material alteration in the recommendations there made.

[39] For the preparation of bordeaux mixture see Bulletin 243 of this Station.

weather favorable to blight. Using the same quantity of bordeaux, frequent light applications are likely to be more effective than heavier applications made at long intervals; e. g., when a horse sprayer carrying but one nozzle per row is used, it is better to go over the plants once a week than to make a double spraying once in two weeks. A good plan is to use one nozzle per row in the early sprayings and two nozzles per row in the later ones.

Those who wish to get along with three sprayings should postpone the first one until there is danger of injury from bugs or flea beetles and then spray thoroughly with bordeaux and poison. The other two sprayings should likewise be thorough and applied at such times as to keep the foliage protected as much as possible during the remainder of the season. Very satisfactory results may be obtained from three thorough sprayings.

A single spraying is better than none and will usually be profitable, but more are better. Spraying may prove highly profitable even though the blight is only partially prevented. It is unsafe to postpone spraying until blight appears. Except, perhaps, on small areas, it does not pay to apply poison alone for bugs. When it is necessary to fight insects use bordeaux mixture and poison together.

AN OUTBREAK OF THE EUROPEAN CURRANT RUST.[1] *

(*Cronartium ribicola* Dietr.)

F. C. STEWART.

SUMMARY.

In September, 1906, the Station currant plantation was found to be abundantly infested with *Cronartium ribicola,* a European rust fungus hitherto unknown to America. It appeared in the form of a conspicuous orange-colored powder on the under surface of the leaves. Of 54 varieties representing three species of Ribes (*R. nigrum, R. rubrum* and *R. aureum*) 48 were more or less affected. It was also found on *R. grossularia* and *R. irriguum.* With the exception of a single affected leaf in a plantation one-half mile west of the Station it was not found outside the Station grounds.

In Europe this rust has been known for fifty years and is widely distributed. As a currant disease it is unimportant. The chief danger from it lies in its effect on white pines. In one of its stages (æcidium) the fungus attacks the trunk and branches of the white pine causing a serious disease called blister rust. Its introduction into America is to regretted. Doubtless it is a recent importation from Europe, but just how it came onto the Station grounds is not known. The only white pines in the immediate vicinity of the affected plantation are two small trees 125 feet west, planted eight years ago. Possibly these trees are the source of infection.

Remedial measures consist, chiefly, in the removal of whichever host (pines or currants) is regarded as of least value. In order to stamp out the disease, if possible, all plants of the genus Ribes on the Station grounds have been destroyed.

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[1] Read in abstract, Dec. 20, 1906, before Section G of the American Assocciation for the Advancement of Science at the fifty-sixth annual meeting, held in New York.

*Reprint of Technical Bulletin No. 2.

CIRCUMSTANCES ATTENDING THE DISCOVERY.

While passing the currant plantation on the Station grounds September 26, 1906, the writer observed an unusual appearance of the foliage on some plants. Upon plucking one of the leaves for examination we were astonished to find the under surface yellow with a rust. Even to the unaided eye it was evident that the rust belonged to the genus Cronartium and upon microscopic examination in the laboratory it proved to be *Cronartium ribicola* Dietr., a currant fungus of common occurrence throughout Europe but hitherto unknown in America.[2]

The plantation in which the rust was found is one devoted to the testing of varieties. It contains about 175 plants and includes 54 different varieties representing three species; viz., *Ribes nigrum, R. rubrum, R. aureum.* Most of the plants were set in the spring of 1903, being transplanted from another plantation about forty rods away. The remainder of the plants were set in the spring of 1904. They varied in height from two to five feet.

Of the 54 varieties, 48 were more or less rusted while the other six were free from rust. The several varieties of black currants, *Ribes nigrum,* were most affected — Monarch, Clipper and Star being among the worst and having almost every leaf thickly covered with rust. In spite of this severe attack of rust the black currants were in full foliage. Some of the red and white varieties, *R. rubrum,* also were severely attacked, but most of them were only slightly affected. The plants of this species had already lost a considerable portion of their foliage from leaf spot, *Septoria ribis.* One variety of *R. aureum* (Jelly) showed traces of rust. Four varieties of *R. rubrum* (Prince Albert, Gondouin White, Stultz and an unknown variety) and two varieties of *R. aureum* (Crandall and Utah Golden) were entirely free from rust.

[2] Dr. J. C. Arthur informs us that the only other record of the occurrence of this fungus in North America is that of a collection made by E. Bartholomew on *Ribes aurcum* in Kansas in 1892. This was a solitary collection in the uredo stage which remained unrecognized until recently. Bartholomew listed the fungus (The Kansas Uredineæ. Reprint from *Trans. Kans. Acad. Science,* 16:193. 1897-'98. Issued June, 1899), as *Uredo confluens* Pers., but Dr. Arthur, who has examined the specimens, pronounced it the uredo of a Cronartium, presumably *C. ribicola.*

The infested currant plantation was adjoined on the west by a plantation of gooseberries containing many different varieties. Only one variety (Pearl) was affected and this but slightly.

In another part of the Station grounds, near the Director's residence and about forty rods east of the infested plantation, there are planted sixteen different species of Ribes, including *R. aureum,* but neither *R. nigrum* nor *R. rubrum.* Of these only one species, *R. irriguum,* was affected. There were two plants of *R. irriguum* and both were severely attacked.

A large quantity of the rusted leaves was preserved. Specimens will be distributed in Fungi Columbiani, Century 24.

DESCRIPTION OF THE FUNGUS.

The fungus *Cronartium ribicola* was first described and named by Dietrich fifty years ago.[3] It appears during the summer and autumn as a conspicuous orange-colored powder on the under surface of the leaves of various species of Ribes (currants and gooseberries). Two formes of spores, uredo- and teleutospores, are produced on Ribes leaves. The uredospores are ellipsoidal to ovoid, 19-35x14-22μ with orange-colored contents and borne in sori forming pustules. The teleutospores are elongated, unicellular and massed together into peculiar orange-colored columnar processes which attain a maximum length of about two millimeters. These processes are usually curved. To the unaided eye they appear like coarse, yellow plant hairs, hence the German name "Filzrost" (felt-rust).[4]

Another form (the aecidium form) of the currant rust fungus occurs on the trunks and branches of Pinus spp., especially the white pine,[5] *Pinus strobus,* producing a disease called blister rust (Blasenrost of the Germans). The pine-inhabiting form was first described by Klebahn in 1887 as a distinct species and by him

[3] Dietrich (10). The number in parenthesis refers to the bibliography.

[4] See Plates VII and VIII.

[5] In Europe *Pinus strobus* is universally known as the Weymouth pine, being named after Lord Weymouth who took up its cultivation actively when it was first introduced into England in 1705. (See *Garden and Forest,* 3:536. 1890.)

named *Peridermium strobi*.[6] Subsequently, through inoculation experiments made by Klebahn and others,[7] it was conclusively proven that *Cronartium ribicola* on the currant and *Peridermium strobi* on the pine are not separate species but only different stages of one and the same fungus.

GEOGRAPHICAL DISTRIBUTION AND ECONOMIC IMPORTANCE.

Cronartium ribicola occurs in several European countries, and probably in India;[8] but has never been found in Australia or in South America and in North America but once as mentioned on page 189, footnote 2.

It was originally described in 1856 from specimens collected in western Russia. Since that time it has been reported from other places in Russia even to the Ural Mts.[9] on the east and to the Caucasus Mts.[10] on the south. In Germany it is common and the injury which it does to the white pine is of considerable economic importance. Klebahn[11] has reported a destructive outbreak of the disease among white pines in the vicinity of Bremen in 1887. Tubeuf,[12] in 1898, stated that specimens of it were to be found all over Germany and that it was destructive in the northeastern part. Among other instances of severe damage he mentions a large nursery near the Holland border in which the culture of white pines had been entirely given up on account of the fungus. In another publication the same author stated that the disease was spreading and becoming a serious menace in Germany.[13] Eriksson[14] describes its epidemic occurrence in Sweden. Bos[15] states that in

[6] Klebahn (23).
[7] Klebahn (24, p. XLIX), (26), (27, p. 31), (29, p. 333), (30, p. 74), (32, p. 16), (35, p. 86); Rostrup (53, p. 187), (54); v. Wettstein (67); Sorauer (58); Eriksson (13, p. 380); v. Tubeuf (64); Hennings (20); Schöyen (56).
[8] Tulasne (66, p. 189), mentions a Cronartium on Ribes in India.
[9] Sorokin (59).
[10] Speschneff (60).
[11] Klebahn (24, p. XLV).
[12] v. Tubeuf (63).
[13] Tubeuf (61).
[14] Eriksson (12).
[15] Bos (5).

Holland it is so abundant that in many localities the culture of white pines is impossible. It is also reported from Belgium,[16] Denmark,[17] Norway,[18] Switzerland,[19] France,[20] Austria[21] and England.[22]

Judging from the European literature on the subject, it appears that as a currant disease *Cronartium ribicola* is regarded as of little importance even in those regions in which it is abundant, but as a disease of white pines it has caused much damage.

American mycologists, believing that it must eventually make its appearance in this country, have been on the lookout for it for many years; but with the exception of the Bartholomew collection previously mentioned (footnote 2, p. 189) it has not been found anywhere in the Americas. No Cronartium on any species of Ribes and no Peridermium on *Pinus strobus* are known to America. The fact that America is the home of the white pine makes the absence of *Cronartium ribicola* especially noteworthy. Magnus,[23] Klebahn,[24] and others have commented upon this and discussed the probable origin of the fungus. The most plausible theory advanced regarding the origin of *Cronartium ribicola* is that its original host was the Swiss stone pine, *Pinus cembra*, and that it was introduced into Germany in recent times from Russia where *Pinus cembra* forms extensive forests. Schellenberg[25] expressed the opinion that it is also indigenous in the Swiss Alps on *Pinus cembra*.

It is altogether probable that the apparent absence of *Cronartium ribicola* from America is real; or at least the fungus cannot have existed here long. It is unlikely that collectors have overlooked it. Both on the currant and on the pine it is conspicuous and readily identified. The horn-like masses of teleutospores are characteristic and serve to distinguish it from other rusts occurring on Ribes leaves.

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[16] Nijpels (44); Marchal (41), (42).
[17] Rostrup (53).
[18] Blytt (7); Schöyen (56).
[19] Fischer (15); Schellenberg (55).
[20] Poirault (51).
[21] v. Wettstein (67); Bubák (8).
[22] Plowright (48), (49), (50).
[23] Magnus (36), (37), (39), (40).
[24] Klebahn (25), (26), (30, p. 155), (34, p. 78).
[25] Schellenberg (55).

PLATE VI.—THE EXPERIMENT STATION CURRANT PLANTATION IN WHICH THE OUTBREAK OF RUST OCCURRED.

PLATE VII.—THE UNDER SURFACE OF RUST-INFESTED CURRANT LEAVES.
A. UREDO AND TELEUTO SORI OF CRONARTIUM RIBICOLA (×4).
B. THE SAME, MORE ENLARGED.

PLATE VIII.—THE CURRANT AND PINE RUST.
Cronartium ribicola.

1, Uredo and teleutospore stages on leaf of black currant; 2, Uredospores, *a*, and teleutospores, *b*, cemented together to form an erect, hairlike structure (×50); 3, Uredospore, (×300); 4, Four teleutospores, two of which are germinating, and one of the germ-tubes has produced four sporidia or secondary spores (×300); 5, Aecidia on bark of white pine; 6, Aecidiospores (×300). (After Massee.)

ORIGIN OF THE GENEVA OUTBREAK.

It would be interesting to know the origin of the outbreak at Geneva, but from the data now in hand it is not possible to locate definitely the original source of infection. It is likely that the fungus was imported with pines rather than with currants or gooseberries, since it is perennial within the stems and branches of the pine, while on Ribes it is confined entirely to the leaves. The only white pines in the immediate vicinity of the diseased currant planation are two small trees standing 125 feet to the west. These were purchased from a Geneva nursery and set eight years ago. From a careful examination of these trees made in November they appeared in thrifty condition without any indication of Peridermium. Nevertheless, they may be the source of infection, notwithstanding their seeming freedom from disease. *Peridermium strobi* should be sought in April and May; by November it is difficult to recognize.

The two trees just mentioned are the only white pines on the Station grounds; and there are no specimens of *Pinus cembra, P. lambertiana, P. monticola* or any other Pinus having leaves in clusters of five. The nearest other possible sources of infection are a 12-feet-high *Pinus strobus* sixty rods east, an aged *Pinus strobus* about eighty rods north and a sixteen-year-old *Pinus cembra* the same distance to the southeast. There are several nurseries in the vicinity of Geneva and it may be that some one of them has imported diseased pine trees. The nearest nursery containing pines liable to the disease is about one-half mile west of the Experiment Station. It contains a block of *Pinus cembra* and some *Pinus strobus* imported from France. Here may be the source of infection. However, contradictory evidence is found in the fact that a plantation of red currants (*Ribes rubrum*) directly across the road from this nursery was practically free from Cronartium. A careful search revealed just one leaf affected with *Cronartium ribicola,* which was in the teleuto stage. Another plantation of red currants between the nursery and the Experiment Station was entirely free from Cronartium. In fact the single affected leaf above mentioned is the only instance in which the Cronartium has been found outside the Station grounds although the neighboring currant plantations

were carefully searched. Thus, the indications are that the source of infection is on the Station grounds.

This raises the question whether it is possible that the outbreak may have resulted from uredo- or teleutospores brought onto the Station grounds with imported currant plants. During the past ten years the Station has made several importations of currant and gooseberry plants, the latest one being from Hexham, England, in the spring of 1904. Can these plants have been the source of infection? It has already been stated that the aecidium stage of *Cronartium ribicola* occurs on certain species of Pinus, especially *P. strobus*. It has been proven that the uredo stage on the currant may start from infection with aecidiospores from the pine; and that the aecidium stage on the pine may result from infection with teleutospores from the currant.[26] Further, it is believed, but not conclusively proven, that aecidiospores can not infect pines and teleutospores can not infect currants. The uredospores may infect currants directly, but they do not survive the winter. In short, in the absence of pines the currant rust can not perpetuate itself. This is the generally accepted view and if it is a correct one the Geneva outbreak of currant rust could not have come directly from imported currants. However, some eminent mycologists have expressed doubt on this point. Eriksson,[27] Fischer,[28] Iwanoff,[29] Nilsson,[30] and Speschneff,[31] have all cited cases of the occurrence of *Cronartium ribicola* on currants in localities where *Pinus strobus* was lacking; and Eriksson,[32] particularly, has expressed the opinion that it may live from year to year on currants entirely independent of the aecidium stage on the pine. Klebahn,[33] on the contrary, believes that this view should not be accepted without thorough investigation. In none of his numerous inoculation experiments was there a recurrence of Cronartium the following season. In our own case the outbreak on currants can not be satisfactorily ac-

[26] See references given in footnote 7.
[27] Eriksson (13 p. 382).
[28] Fischer (15).
[29] Iwanoff (22, p. 99).
[30] Nilsson (45).
[31] Speschneff (60).
[32] Eriksson (13, p. 392).
[33] Klebahn (33).

counted for except on the assumption that the two nearby *Pinus strobus* trees were diseased last spring. It may be possible to determine this point next spring. If it can be proven that these trees were free from Peridermium in the spring of 1906 then it would seem that we have here evidence in support of Eriksson's view; for it is scarcely possible that pine trees sixty rods or more distant can have been responsible for so abundant an infestation.

ATTEMPT AT ERADICATION.

In order to stamp out the disease, if possible, every Ribes plant on the Station grounds has been destroyed. The two white pines standing by the currant plantation, also, will be destroyed if they show the disease next spring. A careful watch will be kept over pines and currants in the vicinity of the Station and in case of the appearance of the disease next season measures will be taken to secure the prompt destruction of all affected plants. Perhaps the disease may be stamped out, but the chances are against it. The writer knows of no record of a successful attempt at the complete eradication of a fungus disease of plants. It is rarely attempted.

Even should this attempt prove successful, it can not be expected that the disease can much longer be kept out of America. Considering the frequency with which pine trees are imported it is a wonder that the disease has not made its appearance here before.

ITS PROBABLE IMPORTANCE IN AMERICA.

It is improbable that growers of currants and gooseberries in America have much to fear from this new disease. Even when currant leaves are abundantly infested with the rust fungus they appear to be but little injured by it. On the Station grounds black currants which were badly infested held their leaves until well into October.

The chief danger from *Cronartium ribicola* lies in its effect on pine trees, particularly the white pine. In parts of Europe it has wrought havoc among white pines and there is no apparent reason why it should be less destructive in America should it become established here. Indeed, it may become even more destructive. It has not infrequently happened that a parasitic fungus introduced

into a new country has become more virulent in its attack and caused greater damage than in its native country.

There is also the possibility that it may extend its list of host plants. In Europe it is known to attack only four species of Pinus;[34] viz., *P. strobus, P. cembra, P. lambertiana and P. monticola,* all of which bear their leaves in clusters of five.

TREATMENT.

Since it is probable that pine trees and Ribes plants are both necessary to the perpetuation of the Cronartium, the destruction of all specimens of either of these two kinds of host must result in the extermination of the rust. Accordingly, the principal method of control recommended by European writers is the destruction of whichever of the two hosts is the least valuable. Wherever there is danger of the disease, currants or gooseberries should not be planted near white pines.

It is possible that on currants and gooseberries the rust might be controlled by spraying with bordeaux mixture, but no experiments have been made. On the Station grounds one application of bordeaux mixture made as soon as the fruit had set apparently had no effect on the rust.

BIBLIOGRAPHY OF CRONARTIUM RIBICOLA AND PERIDERMIUM STROBI.

With the appearance of *Cronartium ribicola* in this country there is likely to come renewed interest in it. In order to facilitate the labors of American mycologists who wish to examine the literature of the subject, the following bibliography has been compiled. It is not quite complete and several of the articles have not been seen by the writer. By far the most important of the references given is Klebahn's book, Die wirtwechselnden Rostpilze, which contains an authoritative resumé of the whole subject with numerous citations of literature.

1. Anonymous. *Cronartium ribicola* Fischer, nov. sp. *Hedwigia,* 11:182. 1872.
2. ——— Weymouth Pine Disease. *Gard. Chron.,* III., 11:736. 1892.
3. de Bary, A. *Bot. Ztg.,* 31:431. 1873.

[34] Klebahn (34).

4. ——— Notiz über *Cronartium ribicola. Bot. Ztg.*, 32:79-80. 1874.
5. Bos, J. Ritzema. Phytopathologisch Laboratorium Willie Commelin Scholten, Verslag 1900. *Landbouwk. Tijdschr.*, 9:77. 1901.
6. ——— Phytopathologisch Laboratorium Willie Commelin Scholten, Verslag 1901. *Tijdschr. Plantenziekten*, 8:22. 1902.
7. Blytt, A. Bidrag til kundskaben om Norges soparter. IV. *Chrisitiana Vid. Selsk. Forh.*, 1896. No. 6.
8. Bubák, Fr. Ein Beitrag zur Kenntnis der böhmischen Peronosporeen, Ustilagineen u. Uredineen. *Verhandl. K. K. zool-bot. Gesell. Wien.*, 47:233. 1897.
9. Dietel, P. Betrachtungen über die Verteilung der Uredineen auf ihren Nährpflanzen. *Centbl. Bakt.* [etc.], II., 12:218-234. 1904.
10. Dietrich, H. A. Blicke in die Kryptogamenwelt der Ostseeprovinzen. *Arch. f. d. Naturk. Liv-Est-und Kurlands,* II., 1:287. 1856.
11. Eriksson, J. Om nagra sjukdomar a odlade växter. *Kgl. Landtbr. Akad. Handl. o. Tidskr.*, 1890. p. 224.
12. ——— Ueber einige Krankheiten kultivierter Pflanzen und über Massregeln zur Beschränkung der Pflanzenkrankheiten. Mitteil. a. d. Experimentalfelde der Kgl. Landb.-Akademie. Nr. 11. Stockholm, 1890. (Abstract in *Ztschr. Pflanzenkrank.*, 1:27-33.)
13. ——— Einige Beobachtungen über den stammbewohnenden Kiefernblasenrost, seine Natur und Erscheinungsweise. *Centbl. Bakt.* [etc.] II., 2:377-394. 1896.
14. Ewert, Dr. Das Auftreten von *Cronartium ribicolum* auf verschiedenen Ribes-Arten in den Anlagen des Kgl. Pom. Instituts zu Proskau. *Ztschr. Pflanzenkrank.*, 13:92-93. 1903.
15. Fischer, Ed. Beiträge zur Kenntnis der Schweizerischen Rostpilze. *Bul. Herb. Boissier,* 6:11. 1898.
16. ——— Die Rostkrankheiten der forstlich wichtigsten Nadelhölzer nach dem heutigen Stande unserer Kenntnis. *Schweiz. Ztschr. Fortsw.*, 1900: 189.
17. Frank, A. B. Die Krankheiten der Pflanzen. Zweite Aufl. 2:186. 1896.
18. Gobi, Chr., und Tranzschel, W. Die Rostpilze (Uredineen) des Gouvernements St. Petersburg, etc. Aus dem Botan. Laboratorium der K. Universität in St. Petersburg. 1891.
19. Hennings, P. Ueber das epidemische Auftreten von *Cronartium ribicola* Dietr. im Dahlemer botan. Garten. Sep.-Abdr. aus Notizblatt des Königl botan. Gartens und Museums zu Berlin. No. 28. 172-175. 24 Feb., 1902.
20. ——— Beobachtungen über das verschiedene Auftreten von *Cronartium ribicola* Dietr, auf verschiedenen Ribes-Arten. *Ztschr. Pflanzenkrank.*, 12:129-132. 1902.
21. Hisinger, E. *Peridermium pini a corticolum* dödande *Pinus strobus. Bot. Notiser*, 1876:75.
22. Iwanoff, K. S. Die im Sommer 1898 bei Petersburg (Russland) beobachteten Krankheiten. *Ztschr. Pflanzenkrank.*, 10:97-102. 1900.
23. Klebahn, H. Beobachtungen und Streitfragen über die Blasenroste. *Abhandl. naturw. Ver. Bremen,* 10:145-155. 1887. (Author's abstract in *Hedwigia,* 27:118-119.)

24. ——— Weitere Beobachtungen über die Blasenroste der Kiefern. *Ber. deut. bot. Gesell.*, 6:XLV-LV. 1888.
25. ——— Zur Kenntnis der Schmarotzer-Pilze Bremens und Norddeutschlands Zweiter Beitrag. *Abhandl. naturw. Ver. Bremen.*, 12:361–376. 1889. (Abstract in *Ztschr. Pflanzenkrank.*, 2:241–242.)
26. ——— Ueber die Formen und den Wirthswechsel der Blasenroste der Kiefern. *Ber. deut. bot. Gesell.* 8:(59)-(70.) 1890.
27. ——— Neue Untersuchungen und Beobachtungen über die Blasenroste der Kiefern. *Hedwigia,* 29:27–35. 1890.
28. ——— Weymouth Pine Disease. *Gard. Chron.*, III., 12:133. Illus. pp. 134, 135. 1892.
29. ——— Kulturversuche mit heteröcischen Uredineen (Schluss). *Ztschr. Pflanzenkrank.*, 2:332–343. 1892.
30. ——— Kulturversuche mit heteröcischen Rostpilzen. III. Bericht. (Fortsetzung). *Ztschr. Pflanzenkrank.*, 5:69–79; (Schluss) 5:149–156. 1895.
31. ——— Kulturversuche mit heteröcischen Rostpilzen. VI Bericht. *Ztschr. Pflanzenkrank.*, 7:325–345. 1897.
32. ——— Kulturversuche mit heteröcischen Rostpilzen. VII. Bericht. *Ztschr. Pflanzenkrank.*, 9:14–26. 1899.
33. ——— Ueber den gegenwärtigen Stand der Biologie der Rostpilze. *Bot. Ztg.*, 56(11): 144–158. 1898.
34. ——— Die wirtswechselnden Rostpilze. pp. 16, 21, 45, 79, 111 and 382. Berlin. 1904.
35. ——— Kulturversuche mit Rostpilzen. XII. Bericht. *Ztschr. Pflanzenkrank.*, 15:65–108. 1905.
36. Magnus, P. Mycologische Bemerkungen. *Hedwigia,* 12:52. 1873.
37. ——— Einwanderung zweier Rostpilze. *Sitzber. Gesell. naturf. Freunde,* 1873: 75; *Bot. Ztg.*, 32:329–332. 1874; *Verh. Bot. Ver. Prov. Brandenb.*, 16:55–60. Sitzung vom 30 Jan. 1874; *Hedwigia* 13:105, 109. 1874.
38. ——— Beziehungen zweier auf Stachys auftretenden Puccinien zu einander. *Ber. deut. bot. Gesell.*, 16:377–385. 1898.
39. ——— Ueber den Rost der Weymouth-Kiefern (*Pinus strobus* L.) *Gartenflora,* 40:452 1891; *Naturw. Rundschau,* 6:477. 1891.
40. ——— Ueber *Cronartium ribicola* Dietr. Notizblatt K. bot. Garten u. Museum Berlin. Nr. 29, p. 183. 1902.
41. Marchal, E. Rapport sur les maladies cryptogamique étudiees au laboratoire de Botanique de l'Institut agricole de Gembloux. Année 1900. Bruxelles. 1901. (Abstract in *Ztschr. Pflanzenkrank.*, 12:238–240.)
42. ——— In Belgien im Jahre 1901 beobachtete pilzparisitäre Krankheiten. *Ztschr. Pflanzenkrank.*, 12:47–49. 1902.
43. Massee, George. A Text Book of Plant Diseases Caused by Cryptogamic Parasites, pp. 233, 408. London and New York. 1899.
44. Nijpels, P., Le Peridermium du Weymouth. *Bul. Soc. centr. forestière de Belgique,* 1900: 577.
45. Nilsson, Alb. Forstligt botaniska undersökningar i sydöstra Nerike 1892. *Tidskrift för skogshushallning,* 1893. (Abstract in *Ztschr. Pflanzenkrank.*, 4:187–188.)
46. Nordstedt, O. *Bot. Notiser,* 1888: 236.

47. Oudemans, C. A. J. A. Révision des Champignons tant supérieurs qu' inférieurs trouvés jusqu'a ce jour dans les Pays-Bas. Verhand. K. Akad. van Wetensch. te Amsterdam 2. sect. deel 2. Amsterdam. 1902.

48. Plowright, C. B. Fungus on Weymouth Pine and on Currants. *Gard. Chron.*, III., 12:44. 1892.

49. ——— *Cronartium ribicola. Gard. Chron.*, III., 12:137, 501. 1892.

50. ——— *Peridermium strobi. Gard. Chron.*, III., 13:425. 1893.

51. Poirault, G. Les Urédinées et leurs Plantes Nourricières. *Journ. de Botanique,* June—Oct., 1890.

52. Prillieux, Ed. Maladies des Plantes Agricoles, 1:275, Paris 1895.

53. Rostrup, E. Fortsatte Undersögelser over Synltesvampes Angreb paa Skovträer i 1883–1888, *Tidsskr. Skovbrug,* 12:175–238. Kjöbenhavn. 1890. (Abstract in *Bot. Centbl.,* 43:353–356.) See also *Tidskr. Skov. brug,* 6:207. 1883.

54. ——— Mykologiske Meddelser (V.) Spredte Jakttagelser fra 1893. Saertryk of *Botanisk Tidskrift,* 19. Kjöbenhavn. 1895. (Abstract in *Ztschr. Pflanzenkrank.* 6:84–85.)

55. Schellenberg, D. H. C. Der Blasenroste der Arve. *Naturw. Ztschr. Land- u. Forstw.,* 2:233–241. 1904. (Abstract in *Centbt. Bakt.* [etc.], II., 13:659.

56. Schöyen, W. M. Beretning om Skadeinsekter og Plantesygdomme i 1894. Christiania 1895. (Abstract in *Ztschr. Pflanzenkrank.,* 6:30–33.)

57. Schroeter, J. Ueber einige Amerikanische Uredineen. *Hedwigia,* 14:167. 1875.

58. Sorauer, P. *Peridermium strobi* Kleb. *Ztschr. Pflanzenkrank.,* 1:183, 366. 1891.

59. Sorokin, N. Notiz über Verbreitung des Cronartium. *Hedwigia,* 15:84–87. 1876.

60. Speschneff, N. N. (Abstract by Iwanoff in *Ztschr. Pflanzenkrank.,* 9:357.)

61. v. Tubeuf, C. Ueber die Verbreitung von Pflanzenkrankheiten. 1. Die Gefahr der Ausdehnung des Rindenblasenrostes der Weymouthskiefer. *Forstl.-Naturw. Ztschr.,* 1897. (Abstract in *Ztschr. Pflanzenkrank.,* 8:170.)

62. ——— and Smith, W. G. Diseases of Plants Induced by Cryptogamic Parasites. p. 382. London, New York and Bombay. 1897.

63. ——— Der Rindenblasenrost der Weymouthskiefer, eine Gafahr für Garten und Wald. *Prakt. Blätter Pflanzenschutz,* 1:11–13. 1898.

64. ——— Infektionsversuche mit *Peridermium strobi,* dem Blasenroste der Weymouthskiefer. Arbeiten aus der Biolog. Abt. f. Land- u. Forstwirtschaft am Kaiserl. Gesundheitsamte, 2:173–175. 1901. (Abstract in *Centbl. Bakt.* [etc.], II., 7:445.

65. ——— Einige Beobachtungen über die Verbreitung parisitärer Pilze durch den Wind. Arbeiten aus der Biolog. Abt. f. Land- u. Forstwirtschaft am Kaiserl. Gesundheitsamte, 2:175. 1901. (Abstract in *Ztschr. Pflanzenkrank.,* 11:139.)

66. Tulasne, L.-R. Second Memoir sur les Urédinées et les Ustilaginées. *Ann. Sci. Nat. Bot.,* 2:77–196. 1854.

67. v. Wettstein, R. Ueber Ergebnisse von Kulturversuchen mit heterōcischen Uredineen. *Verhandl. K. K. zool.-bot. Gesell. Wien.* 40:44. 1890.

REPORT

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TABLE OF CONTENTS.

REPORT OF THE CHEMICAL DEPARTMENT.

I. THE ACTION OF DILUTE ACIDS UPON CASEIN WHEN NO SOLUBLE COMPOUNDS ARE FORMED.*

L. L. VAN SLYKE AND D. D. VAN SLYKE.

SUMMARY.

1. *Object.*— The work of which an occount is presented was undertaken primarily to measure more accurately the amount of acid that combines with casein to form a definite compound insoluble in water, but facts were developed which raised the fundamental question as to whether the action is one of real chemical combination and to this question chief attention is directed.

2. *Outline of method of work.*— Casein is agitated with dilute acids of known strength for given periods of time, the mixture is filtered and the amount of acid taken up by the casein is measured by the decrease in the conductivity of the solution. It was found necessary to work out special formulas in order to calculate conveniently the results of conductivity measurements into terms giving equivalent amounts of acid. In some cases, casein that had taken up acid was treated with water and the acid partially extracted.

3. *General scope of work.*— The behavior of casein was studied (1) with four acids of different dissociating power (hydrochloric, sulphuric, lactic and acetic); (2) with N-125, N-500, N-1000 and N-2000 concentrations of these acids; (3) for contact of different periods of time, ranging from 5 minutes to 48 hours; (4) at different temperatures (0°, 25° and 45° C.); and (5) with dilute so-

*Reprint of Part I, Technical Bulletin No. 3.

lutions of neutral salts (potassium chloride and magnesium sulphate).

4. *Solubility of casein in dilute acids.*—It was necessary first to ascertain conditions under which casein forms soluble compounds with dilute acids in order to avoid such solution. Evidence of solution was shown (1) by viscosity of solution, (2) by behavior of solution on adding alkali, such as opalescent or milky appearance or precipitation, (3) by the xanthoproteic reaction, and (4) by deviation between results obtained by conductivity and by titration methods. In case of solution, titration results are untrustworthy for measuring the amount of free acid in solution because the dissolved proteid neutralizes *per se* part of the alkali used for titration, and also gives up to the alkali any acid with which the proteid may have combined. Little or no solution of casein occurs even on several hours' contact at 0° C. with solutions not stronger than N-500, or at 25° C. with solutions not stronger than N-1000. Degree of solution is increased (a) by concentration of acid, (b) by increase of temperature, and (c) by prolongation of contact. The solvent action of the four acids studied was in the following order, from the strongest to weakest: hydrochloric, lactic, sulphuric and aetic. The rate at which casein dissolves in different acids of the same normality is not proportional to the concentration of the H^+ ions, or to the dissociation, but is disproportionately great for the weak organic acids. From solutions of equal strength, the dissolved proteid takes up a larger proportion of acid than does the undissolved.

5. *General action of acids and casein without solution.*—Casein takes up acids from dilute solutions. For example, one gram of casein shaken with 100 cc. of N-1000 hydrochloric acid for 3 hours, takes from the solution nearly 50 per ct. of the acid. The amount of acid thus taken up is not definite and fixed but varies (1) with the concentration of the acid, (2) with the duration of contact until equilibrium is reached, which requires some hours, (3) with the degree of agitation until equilibrium is reached, (4) with the temperature, and (5) with the kind of acid. Some acid is always taken up, however small the amount of acid used; but the acid is never completely removed from the solution, however large the proportion of casein present.

6. *Equilibrium ratio of reaction.*— The maximum amount of acid absorbed by a gram of casein varies almost directly with the concentration of the acid within the limits used (N-125 and N-1000) in the case of hydrochloric, lactic and acetic acids, so that at equilibrium the ratio of acid in 1 gram of casein to the acid in 1 cc. of surrounding solution is nearly constant. In the case of sulphuric acid the ratio increases with dilution of acid. The equilibrium ratio reached when 1 gram of casein is treated with 100 cc. of N-500 solution at 0°, is 675 for sulphuric acid, 147 for hydrochloric, 80 for lactic and 36 for acetic. Equilibrium is reached in 2 to 24 hours according to (1) the acid used, (2) the temperature, and (3) the degree of agitation. The greater part of the acid reacting is generally taken up in the first half hour or hour. Increase in temperature increases the rate at which equilibrium is approached, but decreases the final amount of acid taken up, when solution of casein does not result at the higher temperature.

7. *Extraction of acid from casein.*— The acid taken up by casein may be extracted by shaking with water. The extraction continues until the equilibrium ratio (concentration of acid in 1 gram of casein divided by concentration of acid in 1 cc. of surrounding solution) is established, and then ceases.

8. *Neutral salts.*— Neutral salts (potassium chloride and magnesium sulphate) are not adsorbed from dilute solution by casein.

9. The behavior of casein with dilute acids, when no solution occurs, suggests three different explanations: (1) an adsorption compound, (2) solution of acid in casein, or (3) a hydrolyzible salt of casein. A careful application of the experimental results to each of these hypotheses indicates that the action appears to correspond in detail only with the characteristics which apply to an adsorption.

10. On the basis of this explanation, the proteid precipitated when milk sours is free casein in which lactic acid is held by adsorption.

INTRODUCTION.

In Bulletin No. 261 it was shown that when base-free casein is suspended for a time in dilute hydrochloric acid and then filtered, the acid is not all recovered in the filtrate. According to the results then obtained, it appeared that one gram of casein, when

thus treated, takes from solution about 5 cc. of N-100 HCl and forms with it a definite compound, which, like the casein itself, is insoluble. The method of determining by titration with standard alkali the amount of acid remaining in the filtrate did not, under the conditions employed, yield results that were more than approximate. It was thought that more satisfactory results could be obtained by measuring the changes in electrical conductivity of acids caused by treating the acids with casein.

The special object of the work described in this bulletin was to secure additional data bearing on the question as to whether casein combines with acids to form insoluble casein salts of acids, a question which has been in dispute for over fifty years and which has an intimate connection with the coagulation of sour milk and also with certain stages of cheese-making. While the basic property of proteids has long been recognized, it is within the past fifteen years that evidence has accumulated, furnishing more specific proof that acids combine with proteids to form chemical compounds; and the more intimate knowledge gained in regard to the constitution of proteïds has constituted an essential part of this evidence. This view is supported by the work of the following investigators: Sjöqvist,[1] Cohnheim,[2] Cohnheim and Krieger,[3] Erb,[4] Bugarszky and Liebermann,[5] Matthews,[6] Osborne,[7] von Rohrer,[8] Panormoff,[9] Hardy,[10] Mellanby[11] and Robertson.[12]

It was found that in general the amount of acid combining with unit mass of a given proteid in solution was not constant, but dependent upon the concentrations of acid and proteid. This was explained by the hypothesis that the proteids act as weak bases, and consequently their combinations with acids hydrolyze. Spiro

[1] *Skand. Arch. Physiol.*, 5:277. 1894.
[2] *Ztschr. Biol.*, 33:489. 1896.
[3] *Ztschr. Biol.*, 40:95. 1900.
[4] *Ztschr Biol.*, 41:309. 1901.
[5] *Arch. Physiol. (Pflüger)*, 72:51. 1898.
[6] *Amer. Jour. Physiol.*, 7:445. (1898.)
[7] *Jour. Amer. Chem. Soc.*, 24:39. 1902.
[8] *Arch. Physiol. (Pflüger)*, 90:368. 1902.
[9] *Jour. Russ. Physiol. Chem. Gesell.*, 31:556.
[10] *Jour. Physiol.*, 33:333. 1905.
[11] *Jour. Physiol.*, 33:373. 1905.
[12] *Jour. Biol. Chem.*, 2:317.

and Pemsel[1] concluded from the lack of constant combining proportions that the reaction between proteids and acids was not a true salt formation, but a case of physical distribution of the acid between proteid and solvent water. In reaching their conclusions, however, they appear to have overlooked the effect of the hydrolysis which is to be expected from salts of weak bases, and the weight of evidence inclines entirely towards the view that proteids form chemical compounds with acids.

In studying the action of acids on proteids, various methods have been used by different workers in measuring the amount of free acid that disappears as such after treatment with proteid. In the case of a soluble proteid-acid product, the compound may be precipitated and the quantity of acid that is held in the precipitate or left in the solution determined by ordinary chemical methods. Titration of the solution has been the method usually employed. As precipitants, Cohnheim and Spiro and Pemsel used ammonium sulphate. Later Cohnheim and Krieger introduced the use of calcium phospho-tungstate. Erb also employed this method, and his results led to the conclusion that proteid-acid salts hydrolyze more completely as their concentration increase, a behavior directly opposite to that of known hydrolizible salts. Von Rohrer, however, showed that the calcium phospho-tungstate method could not give accurate results, because the phospho-tungstic acid, like phosphoric, renders accurate titration impossible. He showed that picric acid and dipotassium mercuric tetraiodide (K_2HgI_4) precipitated acid albumin containing an unvarying equivalent of acid independent of the excess or kind of acid, also of the temperature, and of the precipitant used. He explains this on the ground that while an equilibrium exists between the acid-proteid (Alb Cl) and free proteid (Alb OH),

$$\text{Alb Cl} + \text{HOH} \rightleftharpoons \text{AlbOH} + \text{HCl}$$

only the acid-proteid is sufficiently dissociated to react with the precipitant. As this is precipitated and the equilibrium disturbed, the reaction goes from right to left, forming more Alb Cl, which in turn is thrown down, until no proteid is left in solution, the precipitate being entirely unhydrolyzed acid-proteid. This method gave the

[1] *Arch. Physiol. Chem.*, 26:233. 1898-9.

acid equivalents of the proteids, but, as von Rohrer points out, physico-chemical methods must be employed in order to ascertain the degree of hydrolysis of the proteid and the amount of acid it holds as it exists in solution.

Several physico-chemical methods have been employed to measure the acid combined when no precipitation occurs. Sjöqvist used the method of electrical conductivity. Bugarszky and Liebermann measured, by means of the electromotive force of concentration cells containing acid, the changes in concentration of the latter caused by contact with proteid; they also measured the change in freezing point due to the addition of various amounts of proteid to dilute acid. Cohnheim measured the free acid by the velocity of the catalysis of cane sugar.

However, in the work done by most of the investigators mentioned above, the compounds of proteids and acids which they studied are soluble, unlike the insoluble substance formed by treating casein with dilute acids. Osborne[1] has studied the action of hydrochloric acid upon neutral edestin suspended in water, concluding that it forms a monochloride insoluble in water. Leo[2] states that fibrin forms a series of insoluble compounds with hydrochloric acid. Laxa[3] and Richet[4] are, so far as we know, the only workers who have worked with casein, proceeding upon lines similar to our previous work. Laxa regards the insoluble substance formed by treating casein with lactic acid as a case of chemical combination. He concludes that lactates of casein which contain one per ct. of lactic acid or less are insoluble in water, while lactates of casein with higher content of acid are soluble.

When the proteid-acid substance is insoluble, as in the case of casein with dilute acids, the amount of acid taken up by the casein may be measured by determining through titration how much acid remains in the filtrate after the removal of the insoluble casein-acid substance. The titration method, as used in previous work, gives misleading results, unless the conditions of treatment are such that no casein goes into solution. In case of solution, the amount of

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[1] *Jour. Amer. Chem. Soc.*, 24:39. 1902.
[2] *Ztschr. Physiol. Chem.*, 46:286. 1905.
[3] *Milchw. Zentbl.*, 1:538. 1905.
[4] *Compt. Rend. Soc. Biol.* [*Paris*], 60:650. 1906.

acid in the filtrate, measured as free acid, is too high, since the titration represents not only the acid that has not been taken up by casein but also that which has combined to form soluble compounds and, in addition, the acidity of the dissolved proteid itself. When the work previously published was done, the ease with which casein dissolves in very dilute acids was not fully appreciated, and the conditions then employed permitted some solution, as we have since learned by repeating some of the former work.

When no solution occurs and conditions permit the use of acids sufficiently concentrated for accurate titration, results by titration agree closely with those obtained by measuring electrical conductivity. In order to avoid solution, it was necessary to use dilutions as high as N-1000 or to have the reaction occur at low temperature. In the case of high dilution, accurate titration was impossible, even when solution was prevented, and therefore conductivity measurements were used in all cases as the basis of our work.

When we began the work embodied in this article, we expected simply to measure more accurately the amount of acid that would combine with one gram of casein to form a definite compound insoluble in water; but we soon found the problem less simple than we had supposed. In one set of experiments, we treated varying amounts of casein with a fixed amount of acid, the larger amounts of casein being, theoretically, more than sufficient to take up all the acid, judging from previous results. However, we found that some free acid remained in the filtrate in every case and, moreover, the acid was taken up in different proportions by the casein. Also, in treating casein with acids of different concentrations, it was found that the amount taken up varied with the different concentrations of solution. The phenomena were such as to suggest something else than simple, definite chemical combination; and our study practically resolved itself into an effort to decide what hypothesis was best supported by facts,— whether that of (1) definite chemical combination accompanied by hydrolysis, or (2) solution of acid in proteid, or (3) adsorption.

In order to obtain data which might be utilized in coming to a decision in regard to the kind of action involved, the behavior of casein was studied (1) with acids of different dissociating power,

(2) with acids of different concentrations, (3) for different periods of time, (4) at different temperatures, and (5) with dilute solutions of neutral salts.

The acids used were hydrochloric, lactic, sulphuric and acetic. The concentrations of the acids used were, approximately, N-125, N-500, N-1000 and N-2000.

The periods of time used for keeping casein and acid in contact varied from one minute to forty-eight hours; the periods usually employed were 5, 15 and 45 minutes, 1½, 3 and 6 hours, in the case of experiments at room temperature or higher; while additional periods of 12, 24, and sometimes 48 hours were used in the case of experiments at 0° C. The temperatures used were 0°, about 25° (room temperature) and 45° C. The study of hydrochloric and sulphuric acids was made to cover more details than in the case of the other acids.

DESCRIPTION OF METHODS, APPARATUS AND RE-AGENTS USED.

METHOD OF PREPARING CASEIN.

To 1 liter of fresh, separator skim-milk, we add about 6 liters of distilled water and enough dilute acetic acid (10 to 15 cc. of strong acid diluted with water to a liter) to cause complete precipitation of casein, avoiding any marked excess of acid. The mixture is kept vigorously agitated while the acid is being gradually added. The precipitate is allowed to settle, the supernatant liquid is decanted or siphoned off, after which the precipitate is washed with copious amounts of distilled water, until the wash-water no longer shows an acid reaction to litmus. The precipitate is then treated with just enough dilute ammonia water (about 5 cc. of strong ammonia diluted to a liter) to dissolve the casein, forming a solution neutral to litmus. The solution is diluted to about 6 liters with distilled water and reprecipitated by dilute acetic acid. Much less acid is required for the second and subsequent precipitations than for the first. The precipitate is washed free from acid as before and then redissolved in dilute ammonia. Re-precipitation and redissolving should be performed five or six times. The casein should not be allowed to stand longer than necessary

in contact with either acid or alkali. The final filtration and washing are completed on a Buchner funnel, the precipitate being washed until free from acid. The washed precipitate is then suspended in one liter of N-1000 HCl and agitated for two hours, in order to remove any remaining inorganic salts as completely as possible. Two treatments of this kind are given. The casein is finally washed until free from hydrochloric acid and is then agitated for two or three hours with a liter of very pure water (showing a conductivity not greater than 1.5 to 1.8×10^{-6}), the operation being repeated two or three times until the filtrate shows an increase of not more than 1 or 2×10^{-6} in conductivity, as compared with the conductivity of the wash water used. The precipitate is then treated with about a liter of strong alcohol and ether (these reagents should show no conductivity when mixed with pure water), in order to remove any fat that may adhere to the casein. The precipitate is then dried at room temperature, ground fine in a mortar and finally dried at 45° to 50° C., until the moisture content is reduced to 3 or 4 per ct. Casein thus prepared by us had an ash content of about 0.25 to 0.30 per ct. We used this method of drying, because, according to Laqueur and Sackur,[1] moisture can be completely removed from casein only by heating to a temperature that may alter the nature of the proteid. Correction is made for moisture, so that the amounts used in our work represent water-free casein.

It is important that the casein, when suspended in water, shall show little or no conductivity. With sufficient care one can prepare casein that is practically conductivity-free. Hardy[2] speaks of the impossibility of obtaining suspensions of globulin free from conductivity.

The thorough treatment of the casein with dilute hydrochloric acid and water near the end of the process of preparation rendered it probable that no salts would be left in the casein in a form capable of vitiating results by dissolving or reacting with the acids used under the conditions of experiment. Proof of this was afforded by the agreement of the conductivity and titration results in experiments made under conditions such that solution of proteid

was avoided, as well as by agreement of the equilibria obtained by different methods of treatment. (See Fig. 8 and Table XVIII for examples.)

GENERAL OUTLINE OF METHOD OF MEASURING ACIDITY.

The method of finding the amount of acid taken up by a given weight of casein was, briefly stated, as follows: The casein was agitated in a Jena Erlenmeyer flask with a measured volume of acid of known strength for a given period of time, after which it was filtered and the amount of acid taken up by the casein was ascertained by means of the decrease in the conductivity of the solution. In a part of the work, titration results with N-100 NaOH were obtained for comparison with the conductivity results.

The details of the method will be considered in the following order: (1) Preparation of flasks, (2) preparation of standard solutions, (3) measuring solutions for use, (4) preparation of conductivity water, (5) methods of agitation, (6) introducing casein into the acid solution, (7) filtration, (8) method of measuring conductivity, (9) data illustrating accurracy of method, (10) calculating conductivity results in terms of concentration of acid.

PREPARATION OF FLASKS.

Jena Erlenmeyer flasks holding 200 cc. were used in holding the acid and casein for reaction. It is important to use glassware which on contact with solutions will not affect the conductivity. Jena glassware was found to meet this requirement and it was employed in all operations where solutions were in contact with glassware for any considerable period of time. Before being used, the flasks were carefully cleaned, rinsed with distilled water, then with conductivity water and finally dried in a steam oven.

Rubber stoppers, thinly coated with paraffin, were used in these flasks; the stoppers were thoroughly rinsed with conductivity water and then dried on clean filter paper before being used. A test of the effect of paraffin showed it to be practically without influence upon the conductivity of water.

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[1] *Beitr. Chem. Physiol. u. Pathol.*, 3:206. 1903.
[2] *Jour. Physiol.*, 23:273. 1905.

PREPARATION OF STANDARD SOLUTIONS OF ACIDS.

A solution of N-10 HCl was standardized by the official silver chloride method.[1] A solution of N-10 NaOH was then prepared by titration. By means of this, N-10 solutions of other acids were prepared. The acetic and lactic acids used were of the highest quality manufactured by Kahlbaum; the hydrochloric and sulphuric acids were of the purest grade made by Baker & Adamson. Only water of less than 2.2×10^{-6} conductivity was used in making the standard preparations of acids.

MEASURING SOLUTIONS FOR USE.

In measuring the solutions, carefully calibrated pipettes were used and the solutions were delivered into the flasks with the smallest possible amount of exposure to the air.

PREPARATION OF CONDUCTIVITY WATER.

Water of conductivity as low as 1×10^{-6} was prepared by treating ordinary distilled water with a mixture of sulphuric acid and potassium bichromate and then distilling. To a 12-gallon carboy of ordinary distilled water (of conductivity equal to 15 to 18×10^{-6}) we added in water solution 20 grams of potassium bichromate and 20 cc. of concentrated sulphuric acid, and then allowed the water thus treated to stand about 24 hours before distillation. This was performed with a retort of Jena glass, arranged in the manner described by Hulett.[2] Four liters of the treated water were placed in the retort and the first three distilling over were collected in a Jena glass flask. The conductivity of the first liter of distillate was generally 1.0 to 1.2×10^{-6}, and of the third, 1.5 to 1.8×10^{-6}. A condensing tube of glass, after several liters had been distilled through it, gave as pure water as we were able to get with a block-tin tube. It was found unnecessary to redistil the water from barium hydroxide, since the laboratory distilled water appeared to contain practically no carbon dioxide.

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[1] U. S. Dept. Agr., Chem., Bul. No. 46.
[2] *Ztschr. Phys. Chem.*, 21:297. 1896.

INTRODUCING CASEIN INTO ACID SOLUTION.

The desired amount of acid is first delivered into the reaction flask and then to this is added the weighed amount of casein. In the experiments carried on at 45° and 0° C., the acid solution in the flask was allowed to come to the desired temperature before the casein was introduced.

METHODS OF AGITATING THE MIXTURE OF CASEIN AND ACID.

In most of the experiments made at room temperature, we placed the flasks in a revolving apparatus, which kept the casein in constant motion throughout the acid solution. In the experiments made at 0° and 45° C., the agitation was performed by occasional shaking by hand. When the mixtures of casein and acid were shaken only at intervals, the reaction rate was somewhat slower and less regular than when agitation was continuous, the irregularity being shown by points lying noticeably off their curves occasionally, but the difference was not great and, of course, the equilibrium finally reached was not altered.

METHOD OF FILTRATION.

When the casein has been in contact with the acid as long as desired, the liquid is filtered into a 200 cc. Jena flask through a platinum Gooch crucible. The receiving flasks are cleaned and dried in the manner already described above. The Gooch crucibles, before use, are rinsed with conductivity water, then a thin mat of asbestos, previously suspended in conductivity water, is formed in the bottom of each. Before use the whole is dried in order to prevent any dilution of the filtrate by adherent water. To insure the filtrate further against possible contamination, the precaution is taken to rinse the receiving flask with two portions, of a few cubic centimeters each, of the filtrate first drawn through, these rinsings being thrown away. In this way, one can filter 100 cc. of liquid in less than a minute, thus reducing to a minimum the exposure of the solution to air. Water having a conductivity of 1.5×10^{-6} increased only 0.2 to 0.3×10^{-6} after being passed through such a filter in a blank experiment.

METHOD OF MEASURING THE CONDUCTIVITY OF THE FILTRATE.

The flask containing the filtrate is closed at once after filtration by a paraffined rubber stopper, prepared in the manner previously described; it is then placed in the thermostat at 25° C. and allowed to remain until the solution has reached this temperature, usually about one hour. The electrical conductivity is then measured in an ordinary Ostwald or Arrhenius cell.

After the filtrates in a number of flasks have been brought to the temperature of the thermostat, the conductivities can be taken in rapid succession. We found the following method of manipulation to combine satisfactorily accuracy and rapidity in running a series of measurements:— The cell and electrodes are dried with clean filter paper after examining each filtrate, rinsed with the next filtrate to be tested and then placed in the thermostat, after which some of the solution to be tested is placed in the cell. After the resistance is taken, the solution is stirred with the electrodes a short time to make sure that the solution has reached the temperature of the bath. We rarely observed any change in the second reading.

The reading is then taken with care, using in the resistance box a resistance which brought the knife contact near the center of the bridge, where the error is least. The solution in the cell is replaced by a second portion from the same flask and the reading repeated. The two readings are usually identical. In case of disagreement, a third portion of solution is used, which practically always agrees with the second. In the case of the last portion used, three readings are taken on different parts of the bridge. The results usually agree within a limit of one part in a thousand.

All measurements of conductivity were taken with a calibrated Wheatstone bridge by the usual Kohlrausch method at a temperature or 25° C. + 0.03° C, maintained in a thermostat by an Ostwald regulator.

The capacities of the Ostwald and Arrhenius cells were determined and frequently checked with N-50 and N-500 KCl solutions, respectively. The solutions were made by successive dilutions from a standard normal solution having a specific gravity at 18° C. of

1.04488 (water at 4° C.=1). The potassium chloride had been recrystallized four times from solution in conductivity water and then finally fused.

DATA ILLUSTRATING ACCURACY OF METHOD USED IN EXPERIMENTS.

Results obtained by the method employed could be closely duplicated when the conditions of experiment were uniform. For example, four portions of 100 cc. each of N-125 lactic acid were treated under constant agitation for 20 minutes, each with 1 gram of casein. The percentages of acid taken up, as shown by measuring the conductivities of the filtrates, were 29.73, 29.94, 29.64 and 29.85. The agreement of these figures may be regarded as satisfactory, when we consider the fact that the reaction is still proceeding quite rapidly at the end of 20 minutes and that the exact time of contact was not quite the same in each case, owing to the interval required for removing the flasks from the shaker and filtering. As the reaction approaches equilibrium, the proportion of error decreases.

METHODS OF CALCULATING EQUIVALENT CONCENTRATIONS OF DILUTE ACIDS FROM CONDUCTIVITIES.

It is important, of course, to state the results of conductivity measurements in terms expressing equivalent amounts of acid. The method of Kohlrausch,[1] while convenient to use when only a few calculations are needed, was found unwieldy for our work, even with the mineral acids. In the case of the weak organic acids, the method was practically useless, owing to the number of approximations required in each calculation before reaching an accurate result. Consequently, we worked out two simpler methods, one for the mineral acids and one for the organic, which enabled us to make the necessary calculations with comparative ease and rapidity.

Method for sulphuric and hydrocloric acids.—The purely graphical method is simplest in principle but involves the laborious preparation of very accurate curves. The purely mathematical cal-

[1]Leit. d. Elek., p. 130.

culation is, as already stated, unwieldy. A combination, however, of simple approximate calculation with a relatively small graphical correction avoids both these difficulties. For the mineral acids, we used the formula $x = \frac{c}{R-\Delta}$; $x = \eta \times 10^6 =$ the concentration of the acid based on that of N-1000 as unity; R = the resistance of the acid in the cell; Δ = a graphic correction to R. The formula is based on the fact that, for electrolytes as strong as hydrochloric and sulphuric acids, dissociation is sufficiently complete at dilutions above N-125 to make the resistance approximately inversely proportional to the concentration. If the proportion were exact, the equation, $x = \frac{c}{R}$, would hold good. However, as the concentration increases from the point where dissociation is not complete, R becomes too large to fit the equation exactly, the proportionate excess increasing with the concentration. By subtracting this excess, Δ, from R, we have the equation, $x = \frac{c}{R-\Delta}$, which is exact. The value of Δ can easily be determined with accuracy sufficient for results correct to one pro mil. by graphic interpolation, plotting values of R as abscissae and those of Δ as ordinates. Of course, one can use conductivities as easily as resistances, employing the formula $x = c\,(k - \Delta)$; k = conductivity; but more convenient curves are obtained by the use of resistances. After finding the values of c and Δ for a cell of capacity K, the formula can be used with a cell of capacity K′ by multiplying c and Δ by $\frac{K'}{K}$.

In the case of sulphuric acid, the range of dilution (N-125 to N-8000) was so great that it was found convenient to use two cells and construct a curve for the range over which each was employed. The curves include the correction for the influence of water, since water of the same character and conductivity was employed in finding the values of Δ and in the subsequent experiments. This is of advantage because, when working with mineral acids and bases, it is doubtful whether subtracting the conductivity of the water gives correct results. Ostwald favors ignoring the effect of the water, since the impurity may be of such a nature as even to lower the conductivity.[1] Kohlrausch,[2] on the other hand, remarks in discussing this plan: "So steht ein solches Verfahren vollständig in der Luft."

[1] Physico-Chemical Measurements, translated by Walker, p. 235.
[2] Leit. d. Elek., p. 92.

The value of Δ for hydrochloric acid was determined from the table given below. The series of resistances was taken by repeated dilutions of the solution in the cell by means of calibrated pipettes, the series being checked by repetition and by duplicating the more dilute solutions with those made directly from N-105.8.

TABLE I.—SHOWING VALUES OF Δ FOR HYDROCHLORIC ACID.

EQUIVALENT VOLUME (V)	$x = \frac{1}{V} \times 10^{4}$	R	$\frac{.5905}{x} \times 1698$ = R proportional.	R-R proportional = Δ
105.8	9.440	107.7	106.1	
211.7	4.724	213.1	212.2	1.6
423.4	2.362	425.2	424.5	0.9
846.8	1.181	849.0	849.0	0.7
1694.0	0.5905	1698.0	1698.0	0.0

Calculating the constant of the formula from the resistance at the highest dilution, we have $c = x R = .5905 \times 1698 = 1003$, which gives, as the formula, $x = \frac{1003}{R-\Delta} = \frac{2378K}{R-\Delta \text{ (corrected for K)}}$, in which K equals capacity of cell based on the $\frac{1}{\text{ohm. cm.}}$ unit of conductivity for electrolytes.

Similarly the formula for sulphuric acid is found to be $x = \frac{2415K}{R-\Delta}$, the value of Δ being given below in Table II.

For general use with cells of varrying capacities, it is convenient to prepare a table with values of R and Δ reduced to fit a cell of capacity equal to 1. The value of R and Δ are then transposed to fit a cell of any capacity, K′, simply by multiplying them all by K′, since $\frac{K'}{K} = K'$. The values for sulphuric acid for a cell of unit capacity are given in the following table (conductivity of water $= 1.4 \times 10^{-6}$):

TABLE II.—SHOWING VALUES OF Δ FOR SULPHURIC ACID WITH CELL OF UNIT CAPACITY.

V	$x = \frac{1}{V} \times 10^{4}$	R	Δ
125	8	362.3	60.3
250	4	678.4	74.4
500	2	1,290	82
1000	1	2,498	82
2000	0.5	4,888	57
4000	0.25	9,662	00
8000	0.125	19,320	00

The values of $\Lambda^{25°}$ calculated for sulphuric and hydrochloric acids from the resistances given, after correcting for conductivity of water, agree within a fraction of a per ct. with those of Kohlrausch [1] as corrected by the temperature coefficients of the two acids.[2]

Method for lactic and acetic acids.—The method used in calculating the conductivity results obtaind with lactic and acetic acids into their acid equivalents was, like that employed for the mineral acids, a combination of approximate calculation and graphic correction, the maxima of such corrections being 1.9 per ct. for acetic acid and 5 per ct. for lactic acid.

The purely empirical but convenient method of approximate calculation was based on the following data: Representing the resistance of N-125 acid as R_{125}, etc., it was found for lactic acid that $R_{250} = 1.50\ R_{125}$, while $R_{2000} = 1.58\ R_{1000}$, intermediate ratios ranging between 1.50 and 1.58. The percentage increase caused by doubling the dilution is fairly constant, varying from 50 to 58. For acetic acid the variation is even less. Thus, $R_{250} = 1.44\ R_{125}$ and $R_{2000} = 1.45\ R_{1000}$. Increasing by 100 per ct. the dilution of any solution between N-125 and N-1000 concentrations results in an increase of from 44 to 45 per ct. in the resistance. In general, the ratio between the percentage increase in dilution and the percentage increase in resistance is nearly constant. This relation is expressed by the following simple formula for use in calculation:

$$(1)\quad \log x = \log x_0 - c\,(\log R - \log R_0)$$
$$(2)\quad\quad\quad = \log x_0 - c\,(\log k - \log k_0)$$

These two forms allow one to calculate x from either resistance (1) or conductivity (2). The value of c is determined from either resistance or conductivities: $c = \dfrac{\log x_o - \log x_d}{\log R_d - \log R_o} = \dfrac{\log x_o - \log x_d}{\log k_o - \log k_d}$, in which $x = \eta \times 10^6 =$ concentration sought ($=1$ for N-1000 concentration); $x_0 =$ concentration of the strongest solution to which the formula is applied (N-125 in present case); $x_d =$ concentration of most dilute solution to which

[1] Leit. d. Elek., p. 160.

[2] Ibid. p. 199.

formula is applied (N-2000 in present case); R, R_0 and R_d = the corresponding resistances, while k, k_0 and k_d are the corresponding specific conductivities (most conveniently multiplied by 10^6 for use).

The formula was derived as follows: Assuming the constancy of the ratio between the percentage increments in resistance R and in dilution (or equivalent volume), V, respectively, we have,—(1) $\frac{dV}{V} = c\,\frac{dR}{R}$. Integrating, we have,—(2) $\ln V = c\ln R + \text{const.}$, in which const. $= \ln V_o - c\ln R_o$. (3) $\ln V = \ln V_o + c\,(\ln R - \ln R_o)$. Since $x = V^{-1}$, $\ln V = -\ln x$, and (4) $\ln x = \ln X_o - c\,(\ln R - \ln R_o)$.
$\frac{R}{R_o} = \frac{k_o}{k}$ $\therefore$ $\ln R - \ln R_o = \ln k_o - \ln k$. Substituting $(\ln k_o - \ln k)$ for $(\ln R - \ln R_o)$ in 4, we have,—(5) $\ln x = \ln x_o - c\,(\ln k_o - \ln k)$. As all terms are logarithmic and require multiplication by the same modulus to change to Briggs' logarithm, equations (4) and (5) hold without change for ordinary logarithms and constitute the formula already given. The determination of the constant of integration from values of V_o and R_o renders the equation exact for a solution of x_o concentration, while the determination of c from values X_d and R_d render it exact for a solution of concentration X_d. This formula, with graphic correction, can be employed for mineral as well as organic electrolytes, tho not so simple as the one previously given.

The following values were obtained for the two acids:

	x_o	x_d	R_o	R_d
Lactic acid	8	0.5	2036K	11,610K
Acetic acid	8	0.5	6624K	28,870K

K = capacity of cell.

From these values, the constants of the two formulas were obtained:

	$\log x_o$	c	$\log R_o$
Lactic acid	.9031	1.592	4.0649 + log K
Acetic acid	.9031	1.882	4.4605 + log K

The formulas are exact for the concentrations selected as limits. (N-125 and N-2000) and approximate for intermediate points. The corrections having been determined at a few of these points, the remaining ones were graphically interpolated, plotting as abscissae values of x calculated by the formulas, and as ordinates, the corresponding corrections. These corrections, like those in the formula for mineral acids, include those due to the influence of

water. The conductivity of the latter, for all work with lactic and acetic acids, varied from 1.2×10^{-6} to 1.7×10^{-6}.

TABLE III.—SHOWING CORRECTIONS TO FORMULAS FOR LACTIC AND ACETIC ACIDS.

EQUIVALENT VOLUME (V)	$x = . 10^6$	x CALCULATED FROM RESISTANCE BY FORMULA.		CORRECTIONS TO x CALCULATED.	
		Lactic.	Acetic.	Lactic.	Acetic.
125	8.000	8.000	8.000	±0.000	±0.000
250	4.000	4.140	4.025	—0.140	—0.025
500	2.000	2.102	2.038	—0.102	—0.038
1000	1.000	1.042	1.016	—0.042	—0.016
2000	0.500	0.500	0.500	±0.000	±0.000

The series of resistances, from which the formula constants and intermediate corrections were calculated in the case of these two acids, were taken in the usual manner by dilution in the cell, checking the results by duplicates of the higher dilutions made directly from the lowest, and by running duplicate series.

The values found for the molecular conductivity of lactic acid, after making correction for the conductivity of the water, are considerably higher than those given by Ostwald.[1] We are unable to account for this difference, since we observed all required precautions, using Kahlbaum's c. p. acid and preparing fresh N-10 solutions with which to run duplicate series.

In taking the resistance of lactic acid, it was found necessary to heat the electrodes, as recommended by Whetham,[2] changing the platinum black to gray, before we could obtain accurate readings.

EXPERIMENTAL RESULTS.

While the main purpose of our work was to study the action of dilute acids upon casein when no soluble compounds are formed, it became necessary to ascertain the conditions under which soluble compounds are formed, in order to avoid such solution. We shall, therefore, consider this phase of our work first.

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[1] Kohlrausch. Leit. d. Elek., p. 179.
[2] *Phil. Trans. Roy. Soc. London,* 194:343. 1900.

THE SOLUBILITY OF CASEIN IN DILUTE ACIDS.

The ready solubility of casein in acids of N-10 or N-20 concentration, especially hydrochloric acid, has been a familiar fact for a long time, but little has been done in studying the solubility of casein in acids much above N-100 dilution. Our work shows that casein is appreciably dissolved at 25° C. by hydrochloric and lactic acids of N-1000 dilution, and by N-125 acetic acid. In all cases the solubility is markedly increased by increase of temperature.

Evidence of solution can be furnished by the following observations:

(1). *Viscosity of solution.*— After being treated with casein by the method described on p. 210, acids show marked viscosity. In the case of slight solution of casein, this is shown by the readiness with which foam is produced when the flask containing the filtrate is shaken, and also by the length of time the foam persists. The behavior of the foam is very different in amount and duration from that formed by agitating a solution of acid that contains no dissolved proteid. In the case of more marked solution, viscosity is more readily noticed, and the liquid foams noticeably while being drawn through the filter; it also filters more slowly. In cases of very marked solution, filtration, even by suction through a thin asbestos mat, was difficult and the filtrate consisted largely of foam.

(2) *Behavior of solution on adding alkali.*— The clear filtrate on titration with N-100 NaOH becomes opalescent and varies from that to milky turbidity and even to the formation of a heavy curd-like precipitate, according to the amount of casein in solution. These phenomena appear before neutrality is reached and disappear before sufficient alkali is added to give a permanent color with phenolphthaleïn. In the case of precipitation, the readiness with which the precipitate dissolves varies with the rate at which the alkali is added. When the alkali is added slowly, the precipitate forms large flakes and these, once formed, redissolve quite slowly. On the other hand, if alkali is rapidly added in amount sufficient to redissolve any precipitate, the particles of casein, not having time to form large aggregations, redissolve almost instantly, so that only a transient, opaque milkiness is observed before redissolving takes place.

(3) *The xanthoproteic reaction.*— The presence of dissolved casein in the filtrate is readily shown by the xanthoproteic reaction. For the purpose of making our results comparable, this test was applied in the following manner: We boiled 10 cc. of the filtrate to be examined with 10 cc. of nitric acid (sp. gr. 1.42) and then added about 12.5 cc. (about 2 cc. in excess of neutrality) of a concentrated solution of sodium hydroxide. A blank test was used for comparison in cases where the result of the reaction appeared in doubt.

(4) *Deviation between results by titration and conductivity methods.*— When any casein dissolves, titration of the filtrate shows more acid than does the measurement of conductivity, because titration of the filtrate with alkali measures not only the acid not taken up by casein but also that combined with dissolved proteid, and, in addition, the acidity of the dissolved proteid itself, which in some cases may neutralize even more alkali than the free acid. On the other hand, the error caused in conductivity results by partial solution of proteid can, at most, amount to only a relatively small percentage, because the fixation of free hydrochloric acid, for instance, to form a soluble proteid compound, in which the light and rapidly moving H^+ ion of hydrochloric acid is replaced by the enormously complex and sluggish proteid radicle, results in the loss of most of the conducting power of the acid. Thus, the addition of sufficient egg albumin to combine with all the acid in N-20 HCl solution, forming soluble albumin hydrochloride, results in a decrease of 83 per ct. in the conductivity of the solution.[1] Similarly the combination of hydrochloric acid with globulin results in a decrease of 76 per ct. in conductivity.[2] When solution of casein in acid occurs, the soluble acid proteid has still, undoubtedly, a low conductivity of its own, as in the two cases just mentioned, and this will render somewhat too low the final results that are calculated on the assumption that the combined acid forms only a compound which is, like the insoluble one, entirely non-conducting. The error will, however, be one of a small percentage, particularly when only a fraction of the casein dissolves and the greater part of the acid taken up goes to form the insoluble substance.

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[1] Sjöqvist. *Skand. Archiv. Physiol.* 5:344. 1895.
[2] Hardy. *Jour. Physiol.,* 33:273. 1905.

The titration results, on the other hand, as will be shown presently, may indicate only a small proportion of acid taken up, or even less than none. We made determinations of acid in the filtrates obtained from mixtures of casein and acid in numerous experiments in which we used concentrations varying from N-125 to N-500 HCl, employing both the titration and conductivity meshods as checks upon each other. We found that whenever the filtrate gave a pronounced proteid reaction, the titration results fell below the conductivity results and that the more pronounced the proteid reaction, the greater was the difference between the two sets of results.

In some cases, when the decrease in conductivity showed that a large part of the hydrochloric acid had been removed from solution or combined with casein in a soluble form, titration with alkali showed that the filtrate had actually a *greater* acidity than could be accounted for by the total amount of acid originally used in the experiment. The titration caused a voluminous precipitate and the filtrate showed an intense xanthoproteic reaction in such cases. The increased acidity was due to the acidity of the dissolved proteid itself.

There are, then, two reasons why the determinations of acidity by titration and by conductivity do not give concordant results when the solution contains dissolved proteid, the titration results being in error. First, the dissolved casein-acid compound decomposes at once in the presence of alkali, freeing the acid previously combined. Second, the dissolved proteid also combines with and neutralizes part of the alkali. The acidity of the filtrate, instead of representing only the amount of acid not taken up by the casein, equals the acid not so taken up, *plus* the acid that has combined with casein to form a soluble casein-acid compound, *plus* the acidity of the dissolved proteid. Experiment shows that the solution of a gram of casein in a given volume of acid increases by about 8½ cc. the volume of N-10 NaOH required to neutralize the acid. This also is the amount of alkali required to dissolve and neutralize to phenolphthaleïn one gram of free casein. The acidity of the casein itself appears to be unchanged by solution in dilute acid, whether or not the nature of the casein complex is changed.

Effect of temperature upon solution of proteid, and of solution upon titration results.— The set of experiments described below shows clearly the effect of temperature upon the rate of solution and also the effect of solution upon the accuracy of the titration method as used by Van Slyke and Hart, Laxa, Leo and others. The experiments were performed in the manner already described (p. 210). Flasks containing casein and hydrochloric acid were kept at 0°, 25° and 45° C. in constant-temperature baths; they were shaken at intervals. The titrations were made in duplicate, agreement being within 0.1 cc. of N-100 alkali in all cases. The expression, "acid fixed by casein," used below in Table IV indicates acid taken from the state of solution as free hydrochloric acid, whether the union with casein be physical or chemical or both in part, as is probably the case when partial solution of casein occurs. We used 100 cc. of N-125 HCl for 1 gram of casein. The concentration of the acid used was 7.905 instead of 8, because the factor of the stock solution was a little less than unity. The weights of casein represent water-free casein, correction being made for the amount of moisture present, which was generally 3 to 4 per ct., this plan being adopted in all our work.

In the table below, the results are arranged to show,—

(1) Effect of temperature on the rate of solution of casein in acid (columns 10 and 11).

(2) Effect of solution on accuracy of titration results (compare columns 6 and 9 with reference to 10 and 11).

(3) Effect of solution on amount of hydrochloric acid fixed by casein (compare 5 hour figures for 0°, 25°, and 45°, column 6, with reference to 10 and 11).

TABLE IV.—ACTION OF N-125 HYDROCHLORIC ACID UPON CASEIN.

100 cc. of Acid for 1 gm. of Casein.

		CONDUCTIVITY RESULTS.				TITRATION RESULTS.			TESTS FOR CASEIN IN SOLUTION.	
1	2	3	4	5	6	7	8	9	10	11
Temperature Deg. C.	Time of contact of casein and acid.	Resistance of solution r in ohms.	$\eta \times 10^6$ = concentration of acid (N-1000=1)	Decrease in $\eta \times 10^6$ caused by contact with casein.	$10^6 \times$g.eq's (=cc.N-1000 acid) fixed by 1 gm. casein.	Cc.N-100 NaOH to neutralize 25 cc. filtrate.	Decrease in (7) caused by contact with casein.	$10^6 \times$g.eq's (cc.N-1000 acid) fixed by 1 gm. of casein.	Appearance of filtrate on adding NaOH	Xanthoproteic reaction color.
	0	127.4	7.905	....	....	19.9	....	....	....	....
0°........	5 min..	186.3	5.383	2.522	252.2	13.5	6.4	256	Clear	0
0°........	15 min..	188.1	5.331	2.574	257.4	13.5	6.4	256	Clear..........	0
0°........	45 min..	235.3	4.253	3.652	365.2	10.7	9.2	368	Clear..........	0
0°........	1½ hrs...	247.0	4.050	3.855	385.5	10.35	9.55	372	Opalescent......	Light yellow.
0°........	5 hrs...	267.0	3.744	4.161	416.1	9.55	10.35	414	Milky.........	Light yellow.
25°........	5 min..	245.3	4.079	3.826	382.6	10.60	9.30	372	Opalescent......	Light yellow.
25°........	15 min..	257.4	3.901	4.004	400.4	10.45	9.45	378	Milky..........	Medium yel.
25°........	45 min..	273.0	3.661	4.244	424.4	10.95	8.95	348	Opaque.........	Dark yellow.
25°........	2½ hrs...	284.8	3.509	4.396	439.6	12.75	7.15	286	Precipitate......	Orange.
25°........	5 hrs...	302.3	3.305	4.600	460.0	16.35	3.55	142	Precipitate......	Dark orange.
45°........	5 min..	280.9	3.540	4.335	433.5	14.8	5.1	204	Opaque.........	Orange.
45°........	15 min..	313.0	3.178	4.727	472.7	22.1	—0.3	—11	Heavy precip...	Dark orange.
45°........	45 min..	323.0	3.080	4.825	482.5	23.9	—4.0	—160	Heavy precip...	Dark orange.
45°........	5 hrs...	367.8	2.704	5.201	520.1	38.6	—18.7	—758	Heavy precip...	Dark orange.

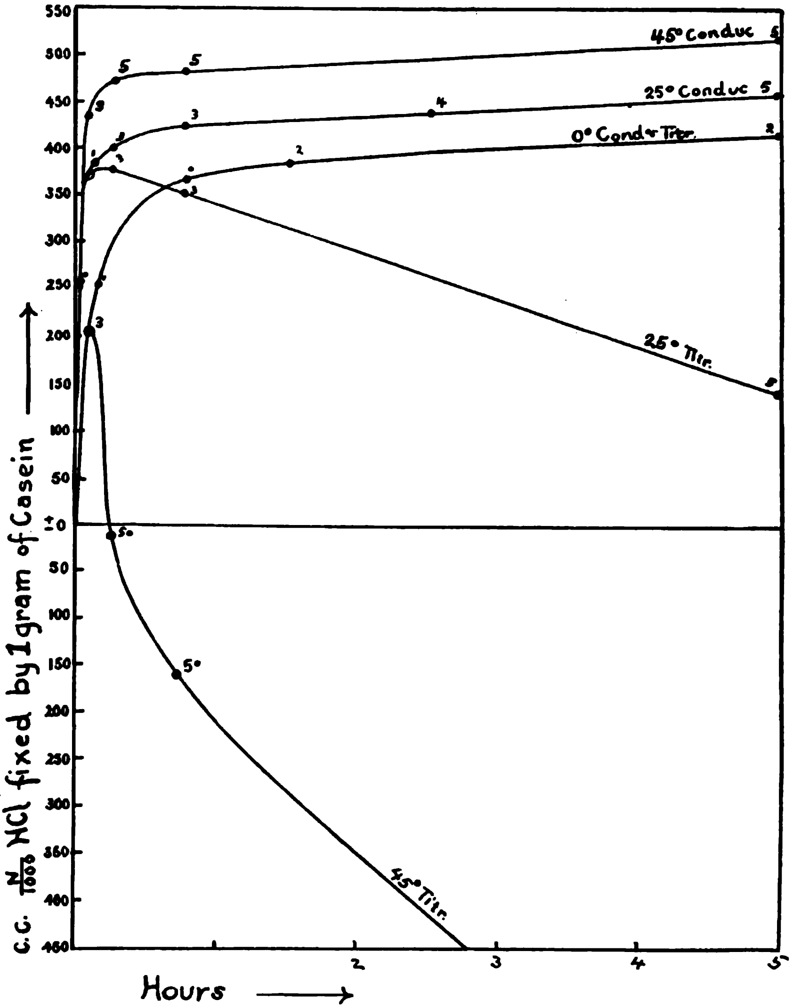

FIG. 6.—Action of $\frac{N}{125}$ HCl on casein. Showing abnormally low titration results at 25° and 45° C. caused by solution of casein.

Explanation of Fig. 6.—The results given in Table IV are expressed in the form of curves in Fig. 6, in which the curves marked "Cond." and having points marked "×" express results obtained by the conductivity method, while the curves marked "Titr." and having points marked "o" express results obtained by the titration method.

The numbers associated with the points × and o express approximate degrees of solution of casein by acid, as indicated below:

No. denoting degree of solution.	Appearance of filtrate on addition of alkali.	Color produced by xanthoproteic reaction.	Mgs. casein in 10cc. of test solution corresponding to color.
0....	clear	none	0 to 0.5
1....	slightly opalescent	slightly yellow	0.6 to 0.9
2....	moderately opalescent	moderately yellow	1.0 to 3.0
3....	turbid, milky	deep yellow	4.0 to 6.0
4....	opaque, some precip.	orange	7.0 to 10.0
5....	heavy precip.	dark orange	10.0 or more
5+..	heavy precip.	dark orange	larger amounts

The figures in the last column were obtained in the following manner: We dissolved 0.5 gram of casein in nitric acid and diluted to 500 cc., each cc. containing 1 mg. of proteid. Different amounts of this solution were diluted to 10 cc. each and tested by the xanthoproteic reaction. The same system of numbers will be uniformly employed hereafter to express approximate degree of solution.

In Fig. 6 it will be seen that at 0° C. there is comparatively slight solution of casein and the results obtained by the two methods, conductivity and titration, coincide. At 25° C., solution becomes marked and the abnormally low curve after the first five minutes furnished by titration results is strikingly apparent. At 45° C., the effect of solution is still more evident. In 15 minutes the amount of dissolved casein makes the acidity of the filtrate actually greater than that of the original N-125 acid used.

The results embodied in Table IV and in Fig. 6 are summarized as follows:

(1) Casein takes up hydrochloric acid from solution. At 0° C., 1 gram of casein takes up from 100 cc. of N-125 HCl, without appreciable solution, the acid in about 50 cc., which is equivalent to

4 cc. N-10 acid, an amount about eight times that found by Van Slyke and Hart (Bulletin No. 261, p. 21).

(2) The formation of a soluble substance from casein by the action of acid is effected when there is an increase in temperature or in the time of contact between the acid and casein. For convenience, we may term this soluble substance soluble acid-casein, without considering the question as to whether it is a salt of casein or a proteolytic product.

(3) More casein goes into solution in 5 minutes at 45° C. than in 5 hours at 0° C.

(4) The soluble substance appears to be a compound of casein and acid. This is indicated by the fact that there is a decrease in the conductivity of the acid simultaneous with the formation of the soluble acid-casein. The decrease is so marked that there is no doubt that the formation of the soluble compound is accompanied by fixation of hydrochloric acid. Doubtless the soluble acid-casein has appreciable conductivity of its own, as already mentioned in the case of other proteids, so that even the conductivity results for the amount of acid fixed are somewhat too low.

(5) The method of determining by titration with alkali the amount of acid remaining unaffected by treatment with casein is thoroughly unreliable in the presence of soluble acid-casein.

In connection with the data here presented, it would seem that the results of the experiments above described ought to emphasize the fact that caution should be used in the determination of free acid by titration in liquids, such, for example, as gastric juice, which have been in contact with proteids. Simon[1] gives titration with sodium hydroxide, using phenolphthaleïn for indicator, as the method for estimating the acidity of the gastric contents; and he also states that the acidity is increased by the ingestion of albuminous food. This would naturally be found so by the titration method, because the proteid in solution would neutralize part of the alkali used in titration and thus increase the amount required.

Effect of temperature and concentration upon the rate at which acids dissolve casein.— We present below in Tables V, VI and VII results indicating the effect of temperature and concentration of

[1] Physiological Chemistry, p. 128. 1904.

acid upon the rate at which acids convert casein into solution. The acids used in our study are hydrochloric, lactic, sulphuric and acetic; the temperatures, 0°, 25° and 45° C.; and the concentrations, N-125, N-500, N-1000 and N-2000. The numbers in the tables indicate degrees of solution, as explained on p. 228 in connection with Fig. 6. The figures on the left in each column express degrees of solution, as shown by the appearance of the filtrate when treated with sodium hydroxide; those at the right indicate the results of the xanthoproteic test.

TABLE V.—SHOWING EFFECT OF TEMPERATURE AND CONCENTRATION UPON RATE OF SOLUTION OF CASEIN BY HYDROCHLORIC ACID.

TIME OF CONTACT.	N-125.						N-500						N-1000						N-2000					
	0°C		25°C		45°C		0°C		25°C		45°C		0°C		25°C		45°C		0°C		25°C		45°C	
5 min.	0	0	1	1	3	4	0	0	0	0	2	2	0	0	0	0	...	...	...	...	...	...	...	...
15 min.	0	0	3	2	5+	5+	0	0	0	0	2	2	0	0	0	0	1	1	...	...	...	...	...	...
45 min.	0	0	3	3	5+	5+	0	0	0	0	3	3	0	0	0	0	2	2	...	...	...	...	...	...
1½ hrs.	2	2	...	...	...	...	0	0	1	0	3	3	0	0	0	0	2	3	...	...	...	...	...	...
2½–3 hrs.	2	2	4	4	5+	5+	1	0	1	1	3	4	0	0	0	0	?	3	...	...	...	...	...	...
5–6 hrs.	3	2	5	5	5+	5+	1	1	3	3	5	5	1	0	1	1	3	3	0	0	0	0	1	2
12 hrs.		3	...	...	*			2		4	...	...	1	1		2	...	...	0	0	0	0	2	2
24 hrs.		4	...	...	*			3		5	...	...	1	1		2	...	...	0	0	0	0	2	2

* Solution nearly complete.

TABLE VI.—SHOWING EFFECT OF TEMPERATURE AND CONCENTRATION ON RATE OF SOLUTION OF CASEIN BY LACTIC ACID.

TIME OF CONTACT.	N-125						N-500						N-1000		
	0°C		25°C		45°C		0°C		25°C		45°C		0°C	25°C	45°C
5 min.	0	1	1	1	3	2	0	0	0	0	1	1	0	0	0
15 min.	1	1	2	1	...	...	0	0	1	1	...	...	0	0	...
45 min.	2	2	3	3	4	4	0	0	2	2	1	1	0	0	1
1½ hrs.	3	2	4	4	4	4	0	0	3	3	3	3	0	0	1
3 hrs.	3	3	4	5	...	...	0	1	4	4	...	...	...	...	...
6 hrs.	4	3	5	5	5+	5+	1	1	...	...	4	4	0	1	2
12 hrs.		4	...	...	...	...		1	...	...	...	...	1	...	...
24 hrs.		4	...	...	...	...		2	...	...	...	...	1	...	...

TABLE VII.— SHOWING EFFECT OF TEMPERATURE AND CONCENTRATION UPON RATE OF SOLUTION OF CASEIN BY SULPHURIC AND ACETIC ACIDS.

(Figures show results of xanthoproteic test only.)

TIME OF CONTACT.	SULPHURIC ACID.					ACETIC ACID.					
	N–125	N–500		N–1000		N–125		N–500		N–1000	
	25°C	0°C	25°C	0°C	25°C	0°C	25°C	0°C	25°C	0°C	25°C
15 min......	0	.....	0	.....	0	.....	0	.....	......	.....	0
45 min......	2	.....	1	.....	0	.....	1	.....	......	.....	0
3 hrs......	2	.....	2	.....	1	.....	1	.....	......	.....	0
6 hrs......	4	0	2	0	1	1	1	0	......	0	0
12 hrs......	......	1	......	0	......	1	......	0	......	0	0
24 hrs......	......	1	......	1	......	2	......	0	......	0	......

The results embodied in Tables V, VI, VII are summarized as follows:

(1) Comparing hydrochloric and lactic acids, it is seen that these two acids have about the same solvent power at 0° C. with the higher dilutions, but with N-125 acid the solvent power of the lactic acid is somewhat greater. Increase of temperature increases the solvent effect of lactic acid less than that of hydrochloric.

(2) Sulphuric acid dissolves casein more slowly than does hydrochloric acid of the same strength and at the same temperatures.

(3) Acetic acid is distinguished for its comparatively slight solvent action on casein at ordinary temperature. This fact is of interest in connection with the method of separating casein from milk by precipitation with acetic acid, the method in general use. Its use involves a more complete separation under uniform conditions, and with less solvent action, than can be attained by use of the other acids studied.

(4) In order to study the effect of the acids under consideration upon casein without dissolving appreciable amounts of casein, it is necessary to use acid solutions as dilute as N-500 to N-2000 and at temperatures not above 25° C.

Action of neutral salts upon the solubility of casein.— In order to test the effect of replacing the H^+ ion, casein was treated at room temperature with N-125 $MgSO_4$ and with N-50 KCl, the same method of treatment being used as with the acids. Even after constant agitation of casein with magnesium sulphate for 6 hours and with potassium chloride for 28 hours, we were unable to obtain any evidence of solution of casein.

The solvent power of the dilute solutions, at least of hydrochloric and sulphuric acids, appears, therefore, to depend upon the presence of H^+ ions. However, since the solvent power of lactic acid is comparable with that of the mineral acids, it suggests that, other conditions being uniform, the concentration of the H^+ ions is not the only factor. As bearing on this point, there is desirable a quantitative test of the solubilities of casein in acids of variable dissociating powers.

The following figures represent the percentage of dissociation and, according to the dissociation theory, the relative concentration of the H^+ ions in solutions of the four acids of the concentrations used:

Equivalent volume.	Percentage of dissociation.			
	Hydrochloric.	Sulphuric.	Lactic.	Acetic.
125	100	82	12.2	4.6
500	100	95	22.7	9.1
1000	100	98	30.7	12.6

The figures for hydrochloric and sulphuric acids are according to Jones and Douglas;[1] those for lactic and acetic acids, from Ostwald.[2]

The results presented in Tables V, VI and VII show that hydrochloric acid has stronger solvent power than sulphuric acid and that lactic is stronger than acetic, results which are in general accord with the dissociation figures preceding, so far as the two mineral and the two organic acids, taken separately, compare with each other; but the dissolving power of the two organic acids, compared with that of the mineral acids, is entirely out of proportion to the relative dissociating powers of the former. Apparently the anions of the organic acids as well as the H^+ ions influence the solvent power. This solvent effect of the organic ions is also shown by Robertson's[3] results. While he found that N-10 solutions of the chloride, sulphate and nitrate of sodium did not dissolve casein appreciably, the acetate, propionate, butyrate and valerate all showed marked solvent action.

[1] *Amer. Chem. Jour.*, 26:434. 1901.
[2] *Ztschr. Phys. Chem.*, 3:174 and 191. 1889.
[3] *Jour. Biol. Chem.* 2:3[illegible].

The solution of casein in dilute acids may be the result of the formation of a soluble casein-acid salt, similar to an amido salt, or it may be the result of the decomposition of the casein molecule, part of which is split off and gives the reaction for proteid in solution. In the latter case, we should expect some change in the properties of the undissolved portion, and this is found to be true. An attempt was made to determine the percentage of casein dissolved at 25° C. by N-125 HCl in 3 hours; the undissolved casein was collected in a Gooch crucible, washed, and dried at 100° C. At the time of filtration the undissolved residue presented a swollen, gelatinous appearance and, when placed in the steam oven to dry, it melted completely, running through the perforated bottom of the crucible. The dried mass looked like dried albumin. The experiment was repeated with the same result. Casein itself can be heated to 120° C. or higher without visible change, and casein that has taken up acid without any solution of the proteid does not appear either to swell or gelatinize, and it can be dried in a steam oven without difficulty. When a part of the casein goes into solution, the undissolved residue appears to undergo some profound change in its properties, and this fact suggests the possibility of molecular decomposition. The scope of our work did not permit us for the time being to carry further our study into details of this interesting change.

THE ACTION OF HYDROCHLORIC ACID UPON CASEIN WITHOUT SOLUTION.

In the foregoing pages we have studied the conditions under which casein goes into partial solution when treated with dilute acids, and also those under which such solution may be avoided. Working under the latter conditions as completely as possible, we now purpose to ascertain to what extent and under what conditions casein takes up acid from dilute solutions when no casein dissolves. It has already been shown by both titration and conductivity methods (Fig. 6, p. 227, curve for 0° C.) that when a gram of casein is shaken with 100 cc. of N-125 HCl at 0° C., about one-half

of the acid is removed from solution before appreciable solution of casein occurs. The fact that the acid is thus taken up to form an insoluble substance with casein being shown, the question remains: Is the taking up of acid by casein a chemical reaction and is the resulting insoluble casein-acid substance a definite chemical compound, or is the process one of adsorption? The results which follow appear to indicate that the behavior of the reaction places it in the class of adsorption reactions, of which the adsorption of dyes and dilute acids by silk forms a parallel example.[1] Our results point to the following general conclusions:

(1st) Contrary to the former belief of Van Slyke and Hart, there is no definite insoluble chemical compound formed; but the amount of acid taken up by casein varies, temperature remaining constant, in proportion to the concentration of the acid in the surrounding solution. The ratio found by dividing the amount of acid taken up by 1 gram of casein by the amount of acid in 1 cc. of the surrounding solution is a constant under uniform conditions and can be established either by acid-casein giving up acid to surrounding water, or vice versa, the acid going either way according to the initial concentration.

(2d) The variation in the amount of acid taken up by casein does not appear to be due to the hydrolysis of a casein-acid salt but rather appears to occur in accordance with the behavior of adsorption reactions, as will be pointed out in later discussion.

In carrying on our study, it was important to employ conditions under which the reaction reaches equilibrium without solvent action on the casein. We found it necessary to use acids not stronger than N-125 and to carry on the experiments at 0° C. in order to avoid solution before the casein had taken up all the acid it could. Even under these conditions, long standing in contact with acids usually resulted in perceptible solution of casein, but to a degree so slight that it did not appear to affect the results, except possibly in the case of the 24-hour periods with N-125 acid.

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[1] Schmidt. *Ztschr. Phys. Chem.*, 15:56. 1894.
Walker and Appleyard. *Jour. Chem. Soc.* [*London*], *Trans.*, 69:1334. 1896.

In the tables following, the concentration of acid in the solutions is given in terms expressing the number of cc. of N-1000 acid equivalent to 1 cc. of solution used. The concentration of acid in the casein is given in terms expressing the number of cc. of N-1000 taken up by 1 gram of casein.

In the third column, the figure representing the amount of N-1000 acid in 1 cc. of solution given for zero time indicates the exact concentration of the acid used in the series, as determined by measurement of its conductivity. This value generally differs slightly from the figures corresponding to the normality given in the first column, because the stock solutions usually possessed factors varying somewhat from unity.

In the fourth column (concentration of acid in casein), the amount of acid taken up by 1 gram of casein in each case is calculated from the difference between the original concentration of the aqueous solution of acid and its concentration after contact with casein for the time stated, as in Table IV. The calculation is based upon the formula $C = \frac{D \times V}{g}$, in which C represents the concentration of acid in casein; D, the decrease in concentration of acid in aqueous solution caused by contact with casein; V, the volume of the solution; and g, grams of casein used.

In the sixth column, the figures express the ratio of the amount of acid in 1 gram of casein to the amount of acid in 1 cc. of the surrounding solution at the end of the period during which the acid and casein were in contact.

TABLE VIII.— SHOWING AMOUNTS OF HYDROCHLORIC ACID TAKEN UP AT 0°C. BY CASEIN IN CONTACT WITH SOLUTIONS OF VARYING CONCENTRATION.

PROPORTIONS AND APPROXIMATE NORMALITY OF ACID USED.	Duration of contact	Concentration of acid in water (=cc. N-1000 acid in 1 cc. solution).	Concentration of acid in casein (=cc. N-1000 acid in 1 gm. casein).	Percentage of acid in original solution taken up by casein.	Ratio of conc'n acid in casein to conc'n acid in water.	Degree of solution of casein.
N-2400	0	.4168	0	0	0	....
200 cc.	3 hrs	.2848	26.4	31.7	92.7	0
for 1 gram	6 hrs.	.2683	29.7	35.6	110.6	0
of casein	12 hrs.	0.2400	35.4	42.4	147.7	0
	24 hrs.	.2406	35.2	42.3	146.4	0
N-1000	0	.9986	0	0	0	....
200 cc.	15 min.	.8221	35.3	17.7	42.9	0
for	45 min.	.8172	36.3	18.2	44.4	0
1 gram	1½ hrs.	.7565	48.4	24.2	64.4	0
of	3 hrs.	.6631	67.1	33.6	101.3	0
casein	6 hrs.	.6313	73.4	36.7	116.2	0
	10 hrs.	.6112	77.5	38.8	131.3	1
	24 hrs.	.5915	81.4	40.7	142.8	1
N-500	0	1.986	0	0	0	....
200 cc.	15 min.	1.670	63.2	15.9	37.8	0
for	45 min.	1.570	83.2	21.0	53.0	0
1 gram	1½ hrs.	1.453	106.6	26.8	73.3	0
of	3 hrs.	1.383	120.6	32.0	93.9	1
casein	6 hrs.	1.182	160.8	40.6	136.2	1
	10 hrs.	1.176	162.4	40.9	138.0	2
	24 hrs.	1.142	168.8	42.5	147.5	3
N-125	0	7.905	0	0	0	....
	15 min.	5.331	257.4	32.6	48.2	0
100 cc.	45 min.	4.253	365.2	46.2	85.8	0
for	1½ hrs.	4.050	385.5	48.8	95.1	2
	5 hrs.	3.744	416.1	52.6	111.2	2
1 gram	0	*7.993	0	0	0	....
of	12 hrs.	3.306	468.7	58.6	141.8	3
casein	24 hrs.	{3.188 / 3.195	{480.5 / 479.8	{60.1 / 60.0	{150.8 / 150.2	4 / 4

The following statements summarize the results presented in Table VIII:

(1) At 0° C. casein takes up increasing amounts of acid for about 24 hours, when equilibrium appears to be practically established, as is shown by the fact that the curves in Fig. 7 approach a horizontal position when the abscissae denote that length of contact between acid and casein.

(2) The final amount of acid taken up by 1 gram of casein varies in proportion to the concentration of the surrounding acid solution, as is shown by the 24-hour results in the fourth column. With the range of concentrations of hydrochloric acid employed,

* Acid of 7.993 concentration was used for last two experiments of the N-125 series. The percentage of acid taken up from the N-125 solution is greater because only 100cc. of solution were used. The ratio reached (column 6) is about the same.

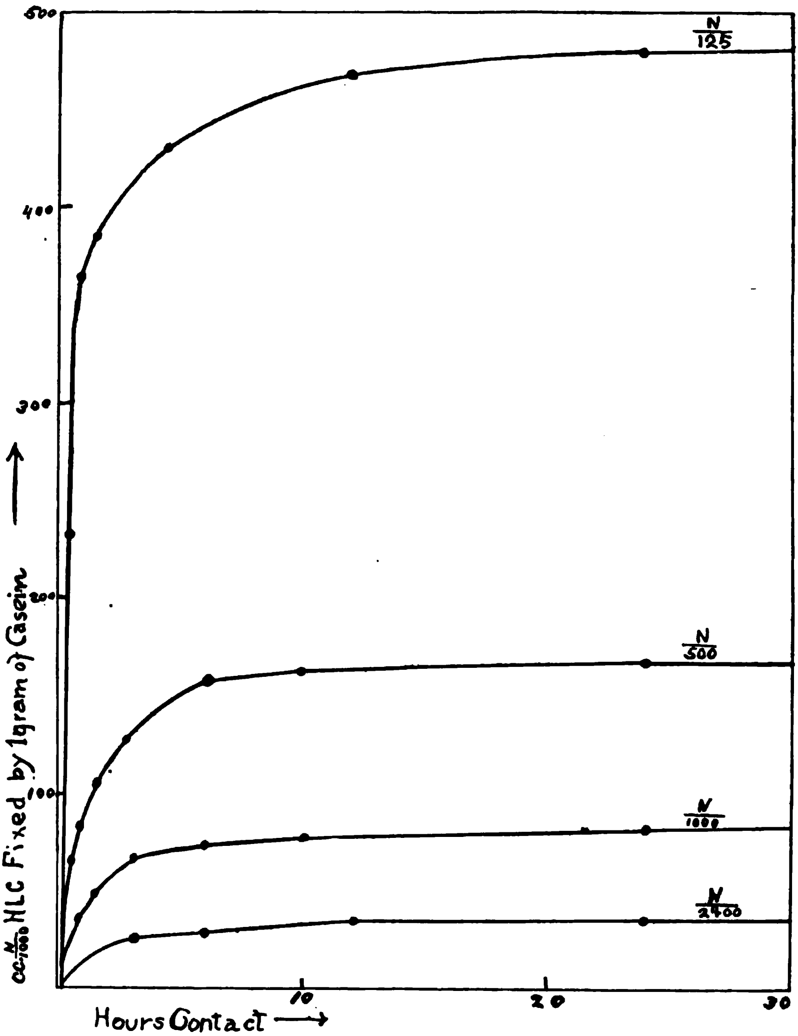

FIG. 7.—Amounts of HCl taken up at 0° by casein in contact with different concentrations. Showing rate of reaction, dependence of final amount of acid taken up upon the concentration used and absence of definite combining proportions.

the final amount of acid taken up by 1 gram of casein varies from the equivalent of 35.36 to 480.3 cc. N-1000 HCl, which amounts were taken up by casein in contact with solutions of acid whose final concentrations were 0.2400 and 3.192 respectively.

(3) If we divide the amount of acid contained in 1 gram of casein by the amount of acid contained in 1 cc. of the surrounding solution at equilibrium, we obtain a ratio, about 147, which is approximately constant, as shown in the sixth column. The lower value, 142.8, obtained with N-1000 acid is probably due to incomplete attainment of equilibrium. The slightly higher result in the case of N-125 acid is to be expected, since appreciable solution of proteid occurs.

(4) The acid, however small the amount used, was in no case completely taken up by casein, but the ratio of acid in casein to acid in surrounding solution approaches an equilibrium constant, about 147.

The results given in the fourth column of Table VIII are expressed in Fig. 7 in the form of curves, which illustrate the fact that the process by which casein takes up acid does not follow the law of definite combining proportions, and that the amount of acid fixed by a gram of casein in the presence of an excess of acid is not constant, but increases with increasing concentration of acid.

Amount of acid taken up by casein dependent upon the concentration of acid present.— In order to illustrate more fully the fact that the amount of acid taken up by 1 gram of casein is dependent, not upon the absolute amount of acid present, but upon the concentration, we give the data embodied in Table IX. The three series of experiments were carried on at different times and for different purposes, which accounts for the lack of uniformity in the time intervals used. It will be noticed that, while the initial concentration of the acid in the third series is twice that of the others, the final concentrations are fairly comparable in all three cases, which is due to the larger relative proportion of casein used in the third series. The mixtures were shaken constantly for the periods indicated and kept at 25° C.

TABLE IX.— SHOWING RELATION OF AMOUNTS OF HYDROCHLORIC ACID FIXED BY CASEIN TO CONCENTRATION OF ACID, 25°C.

Proportion and approximate normality of acid used.	Duration of contact.	Concentration of acid in water (=cc. N-1000 acid in 1cc. solution).	Concentration of acid in casein (=cc. N-1000 acid in 1 gm. casein).	Percentage of acid in original solution taken up by casein.	Ratio of conc'n acid in casein to conc'n acid in water.	Degree of solution of casein.
Series 1 N-2000 828 cc. for 1 gram of casein	0 30 min. 1 hr. 2 hrs. 4 hrs.	.4985 .4597 .4550 .4507 .4476	0 32.1 36.0 39.7 42.1	0 7.8 8.7 9.6 10.2	0 69.9 79.1 87.8 94.1	.... 0 0 0 0
Series 2 N-2000 400 cc. for 1 gram of casein	0 1 hr. 2½ hrs. 5 hrs. 7 hrs.	.4985 .4156 .4064 .4050 .4011	0 33.2 36.8 37.4 39.0	0 16.6 18.5 18.8 19.5	0 79.8 90.6 92.4 97.1	.... 0 0 0 0
Series 3 N-1000 100 cc. for 1 gram of casein	0 15 min. 50 min. 1½ hrs. 3 hrs.	.9970 .5556 .5333 .5181 .5066	0 44.1 46.4 47.9 49.0	0 44.3 46.5 48.0 49.2	0 79.4 87.0 92.4 96.8	.... 0 0 0 0

The results embodied in the preceding table are also shown in Fig. 8 in the form of curves A and B. It is noticeable that the initial rate at which acid is taken from N-1000 solution is greater than from N-2000, as would be expected, but the two curves approach nearly the asymptote. The points (× and °) for the two N-2000 solutions lie on the same curve A.

Extraction of hydrochloric acid taken up by casein.— The reaction by which casein fixes acid is reversible. By treating with pure water casein that has taken up acid, part of the acid passes from the casein back into the surrounding water.

The method of performing the experiment was as follows: In weighed Jena flasks were placed 1-gram portions of casein and 100 cc. portions of N-500 HCl. The mixtures were shaken continuously for 30 minutes, in order to allow the casein to take up acid under conditions not permitting appreciable amounts of casein to go into solution. The mixtures were then allowed to settle for about 5 minutes and the supernatant liquid decanted as completely as possible through weighed Gooch crucibles, into which the decantation usually carried 10 to 20 milligrams of casein. The filtrate (1) was kept for examination. The crucibles were dried and weighed in order to find out how much casein had escaped from the flask

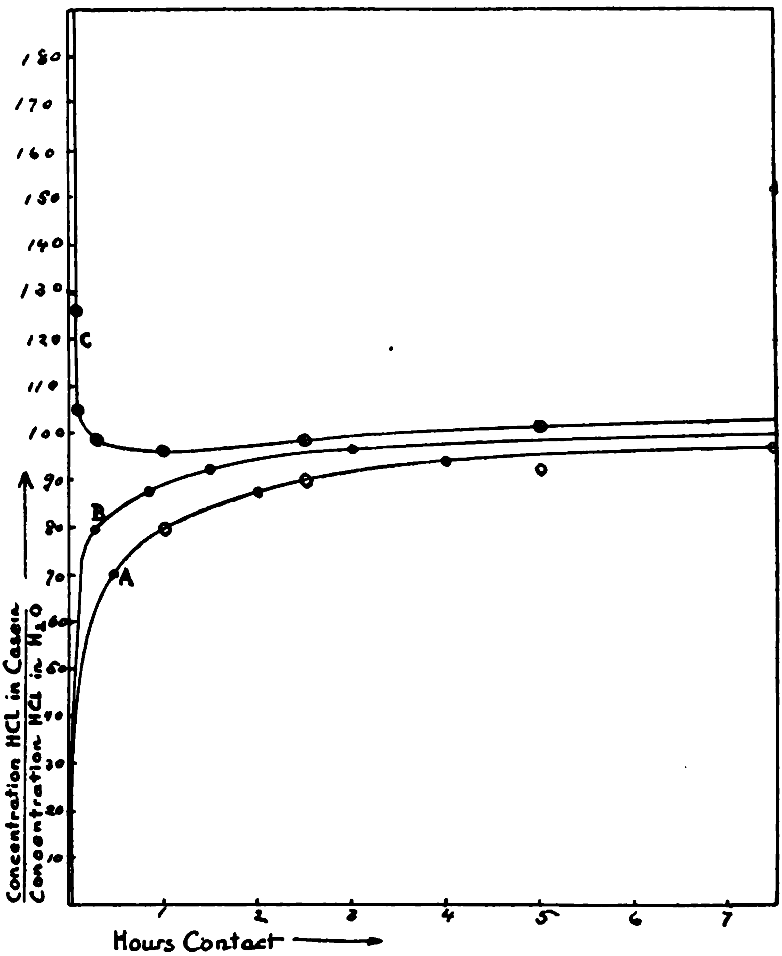

FIG. 8.—Showing relation (curves A and B) of amounts of acid fixed at 25° to the concentration of acid in surrounding solution. Curve C shows rate of extraction of acid from casein that had taken up acid, and attainment of practically same equilibrium as when casein takes acid from solution (curves A and B). See tables IX, X, XI.

during decantation. The flasks with contents were weighed after decantation in order to find how much free acid solution adhered to the casein particles and the walls of the flasks; the amount varied from 2 to 4 cc. To the casein left in each flask there were then added 100 cc. portions of pure water, and the mixtures were shaken for the different periods of time, one minute to five hours, as indicated in Table XI, column J. They were then filtered again (filtrate 2). The amount of acid in each filtrate was determined by conductivity measurements. From the first filtrate were obtained the data necessary to determine how much acid had been taken up by the casein to form the insoluble acid-casein, when shaken 30 minutes with acid. From the second filtrate were obtained the data required to determine the amount of acid extracted from the insoluble acid-casein by treatment with pure water for the different periods of time given. The results were corrected for the amount of casein that escaped by decantation and also for the amount of free acid that remained adhering to the casein and the flask at the first filtration. The detailed results of the work are given below in Tables X and XI.

TABLE X.—SHOWING AMOUNTS OF ACID TAKEN UP BY CASEIN, WITH CORRECTION FACTORS.

A	B	C	D	E	F	G	H
No. of Experiment.	Concentration of acid in filtrate 1 (=cc. N-1000 acid in 1 cc. solution).	Concentration of acid in casein (=cc. N-1000 acid in 1 gm. casein) = 100 (1.982–B).	Grams of acid-casein lost in decanting.	Grams of acid-casein left in flask (=1–D).	Cc. N-1000 acid left in acid-casein before extraction (=CXE)	Cc. solution adhering to acid-casein and flask.	Cc. N-1000 acid in adherent solution (=BXG).
0 and 1	.956*	102.6	.0164	.9836	100.9	3.55	3.39
2	.959	102.3	.0074	.9926	101.5	3.44	3.30
3	.964	101.8	.0165	.9835	100.1	3.38	3.26
4	.971	101.0	.0100	.9900	100.1	4.81	4.67
5	.958	102.4	.0080	.9920	101.6	3.24	3.19
6	.955	102.7	.0143	.9857	101.2	3.57	3.42

* The concentration of the acid used was 1.982 before contact with casein.

TABLE XI.—SHOWING RESULTS OF EXTRACTION OF ACID FROM ACID CASEIN BY WATER.

I	J	K	L	M	N	O	P
No. of Experiment.	Duration of contact between acid-casein and water.	Concentration of acid in filtrate 2 (=cc. N-1000 acid in 1 cc.).	Total cc. N-1000 acid in solution (=conc. X vol. =K X[100+G]).	Cc. N-1000 acid extracted from acid-casein (=L—H).	Cc. N-1000 acid left in casein (=F—M).	Concentration of acid in casein $(=\frac{N}{E})$.	Ratio of conc'n acid in casein to conc'n acid in water. $(=\frac{O}{K})$.
0	0	(.0327)	3.39	0	100.9	102.6	3130.0
1	1 min.	.4594	47.58	44.19	56.9	57.8	126.0
2	5 min.	.5057	52.28	48.98	52.5	52.9	104.6
3	15 min.	.5170	53.46	50.20	49.9	50.7	98.1
4	1 hr.	.5243	54.94	50.27	49.8	50.3	95.9
5	2 hrs.	.5232	54.12	50.93	50.7	51.1	97.8
6	5 hrs.	.5139	53.22	49.80	51.4	52.2	101.5

The following statements summarize the results embodied in Tables X and XI:

(1) When casein that has taken up acid is treated with water, it begins to lose acid rapidly to the surrounding water, and in 1 minute, under the conditions of the experiment, nearly one-half of the acid contained in the casein is extracted.

(2) The acid continues to pass from the casein into the water until a certain ratio is reached between the concentration of acid in the casein and the concentration of acid in the surrounding water, when equilibrium is established. The ratio is practically the same as the one found by treating casein with acid until equilibrium is established, the final conditions of temperature, concentration and proportions being equal. Compare values of ratios in column P, Table XI, with those of Table IX for three or more hours.

(3) It makes no difference whether all the acid is in the casein or in the water at the start; it divides itself between the two in a ratio which, for constant conditions, is constant.

(4) For illustration and comparison, we can use the results embodied in Table IX, Series 3, in which the final conditions of temperature, concentration and proportions are nearly the same as in the case of the results presented in Table XI. In both cases the ratio of concentration of acid in casein to that in water, when reached under similar conditions, is practically the same (that is, about 97) at the time equilibrium is established. The comparison is quite strikingly shown by the curves of Fig. 8, B representing the

result of treating pure casein with acid, and C representing the result of treating with water casein that had taken up acid.

It will be noticed that the ratio tabulated in column P, Table XI, reaches a minimum in one hour and then gradually increases. This increase is probably due to the formation of traces of dissolved casein, which, like acid globulin and albumin, as already mentioned, is doubtless a relatively weak conductor. The fixation of a very small amount of free acid in the form of soluble acid-casein would cause a noticeable decrease in the conductivity of a solution so dilute. In the second filtrate of No. 6, the xanthoproteic reaction showed traces of dissolved proteid.

Effect of temperature upon the action of casein in taking up hydrochloric acid.—The effect of increase of temperature is shown by a comparison of the data contained in Tables XII and XIII following, with those in Tables VIII and IX. The time of contact in the experiments was not extended beyond 6 hours in most cases, because the casein undergoes marked solution when contact is prolonged at higher temperatures (25° and 45° C.) even in the case of very dilute acid. The agitation was performed by hand at intervals and was as nearly uniform as possible in all cases, except that with N-2000 acid at 25° C. the flasks were constantly in motion on the shaker.

TABLE XII.—SHOWING AMOUNTS OF HYDROCHLORIC ACID TAKEN UP BY CASEIN AT 25°C.

Proportions and approximate normality of acid used.	Duration of contact.	Concentration of acid in water (=cc. N-1000 acid in 1 cc. solution).	Concentration of acid in casein (=cc. N-1000 acid in 1 gm. casein).	Percentage of acid in original solution taken up by casein.	Ratio of conc'n acid in casein to conc'n acid in water.	Degree of solution of casein.
N-2000	See Table	IX.				
N-1000	0	.9766	0	0	0	....
200 cc.	15 min.	.7330	48.7	25.0	66.5	0
for 1 gram	45 min.	.6971	55.9	28.7	80.2	0
of	1½ hrs.	.6735	60.6	31.1	90.0	0
casein	3 hrs.	.6594	63.4	32.5	96.0	0
	6 hrs.	.6368	67.9	34.8	106.7	1
N-500	0	1.984	0	0	0	....
200 cc.	15 min.	1.569	83.0	20.9	52.9	0
for 1 gram	45 min.	1.332	130.4	32.8	97.8	0
of casein	1½ hrs.	1.281	140.6	35.4	109.7	1
	3 hrs.	1.262	144.4	36.4	114.4	1
	6 hrs.	1.247	147.4	37.1	118.2	2
N-125	0	7.907	0	0	0	....
100 cc.	5 min.	4.079	382.8	48.4	93.9	1
for 1 gram	15 min.	3.901	400.6	50.6	102.7	2
of casein	45 min.	3.661	424.6	53.7	116.0	3
	2½ hrs.	3.509	439.8	55.6	125.4	4
	5 hrs.	3.305	460.2	58.2	139.3	5

TABLE XIII.—SHOWING AMOUNTS OF HYDROCHLORIC ACID TAKEN UP BY CASEIN AT 45°C.

Proportions and approximate normality of acid used.	Duration of contact.	Concentration of acid in water (=cc. N-1000 acid in 1 cc. solution).	Concentration of acid in casein (=cc. N-1000 acid in 1 gm. casein).	Percentage of acid in original solution taken up by casein.	Ratio of conc'n acid in casein to conc'n acid in water.	Degree of solution of casein.
N-2000	0	.4980	0	0	0	....
828 cc. for	30 min.	.4558	34.8	8.4	76.4	0
1 gram of	1 hr.	.4530	37.1	9.0	81.9	0
casein	4 hrs.	.4411	47.0	11.4	106.4	0
N-1000	0	.9928	0	0	0	....
200 cc.	15 min.	.7782	42.9	21.6	55.2	1
for 1 gram	45 min.	.6676	65.0	32.7	97.4	2
of	1½ hrs.	.6087	76.8	38.6	126.2	3
casein	3 hrs.	.5808	82.4	41.4	141.9	3
	6 hrs.	{.5544 .5526	{87.7 88.0	{44.1 44.2	{158.1 159.3	{3 3
N-500	0	1.984	0	0	0	....
200 cc.	15 min.	1.408	115.2 (108)*	29.0	81.9	2
for	45 min.	1.288	139.2 (106)	35.1	108.1	2
1 gram	1½ hrs.	1.230	150.8 (76)	38.0	122.6	3
of	3 hrs.	1.171	162.6 (50)	41.0	135.6	3
casein.	6 hrs.	1.132	170.4 (20)	42.9	154.0	4
N-125	0	7.905	0	0	0	....
100 cc.	5 min.	3.540	433.5 (204)*	55.2	123.3	3
for 1 gram	15 min.	3.178	472.7 (—12)	59.8	148.7	5
of	45 min.	3.080	482.7 (—160)	61.1	156.7	5+
casein.	5 hrs.	2.704	520.1 (—758)	65.8	192.8	5+

The results embodied in Tables XII and XIII, including temperature results also in Tables VIII and IX, are expressed in the form of curves in Figs. 9, 10, 11, and 12. The numbers above different points in the curves indicate the degree of solution, as explained on p. 227 in connection with Fig. 6. An inspection of the tables and of Figs. 9-12 enables us to summarize the results as follows:

*Figures in parentheses give results obtained by titration method and illustrate the effect of solution of proteid upon such results, as already shown (p. 223).

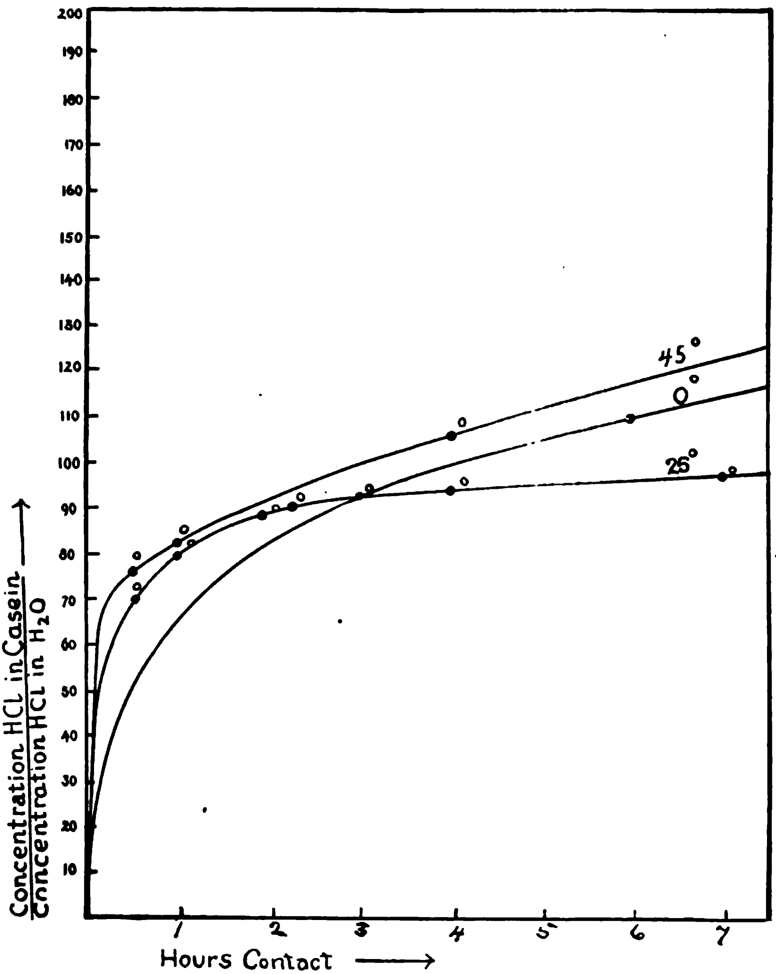

FIG. 9.—Effect of temperature on action of $\frac{N}{2000}$ HCl on casein. Points marked ° signify no solution of casein detected.

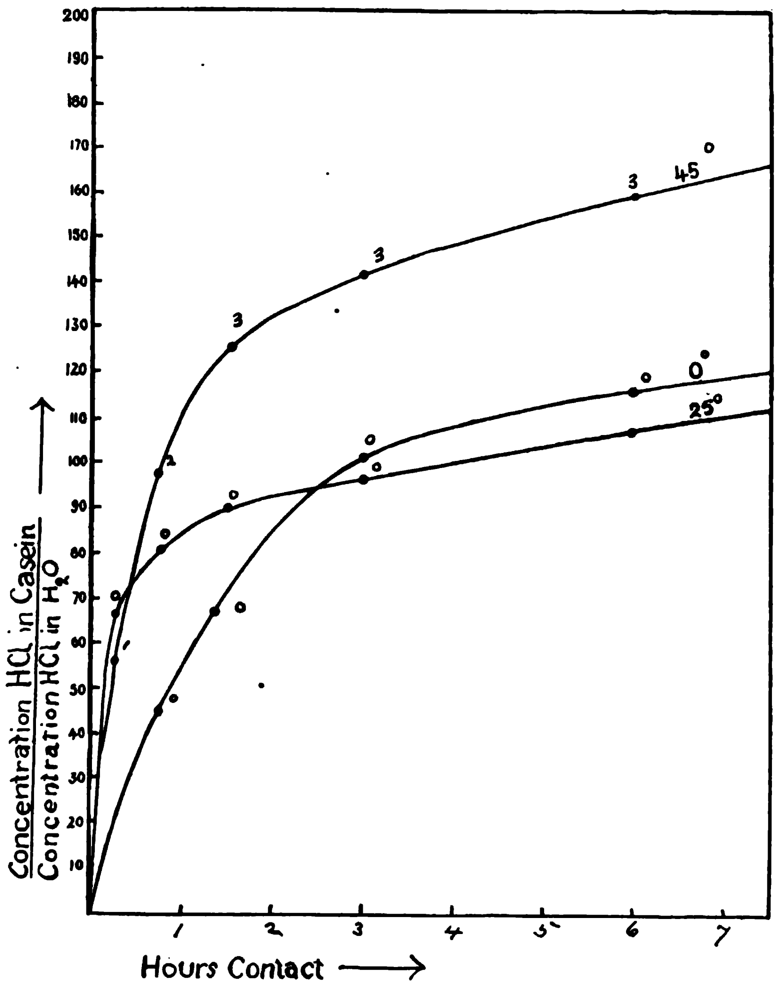

FIG. 10.—Effect of temperature on action of $\frac{N}{1000}$ HCl on casein. The numbers 0, 1, 2, etc., represent relative degrees of solution of casein. (See p. 228.)

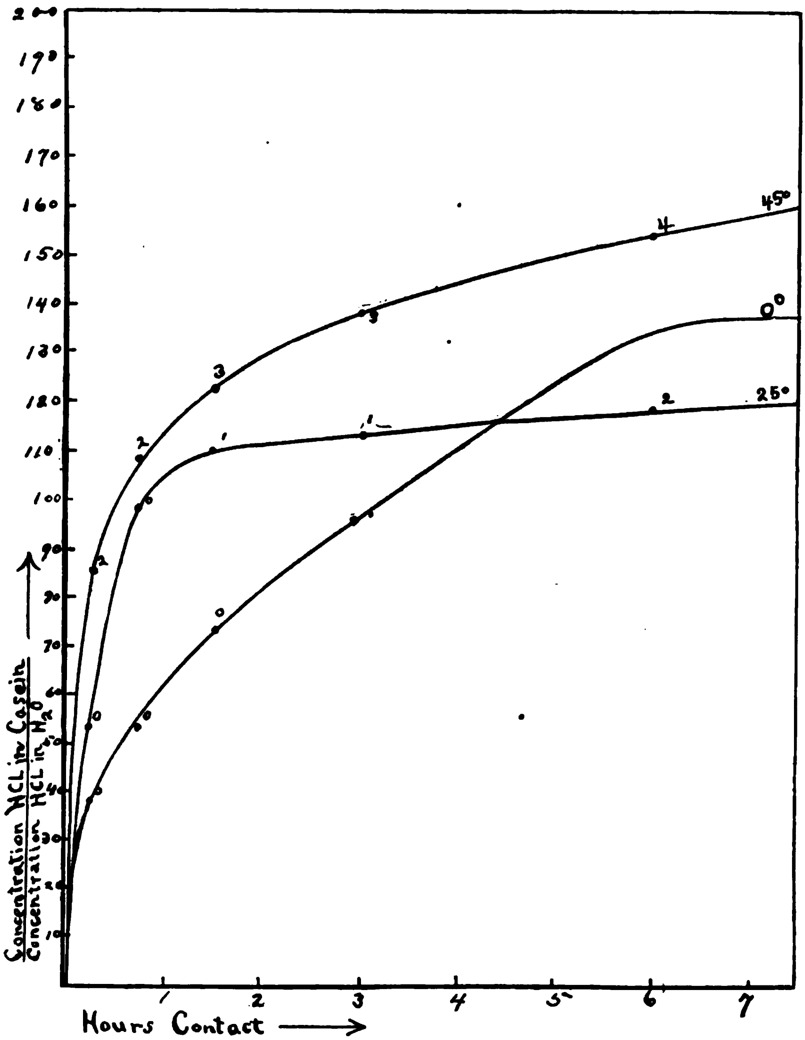

FIG. 11.—Effect of temperature on action of $\frac{N}{500}$ HCl on casein. The numbers 0, 1, 2, etc., represent relative degrees of solution of casein. (See p. 228.)

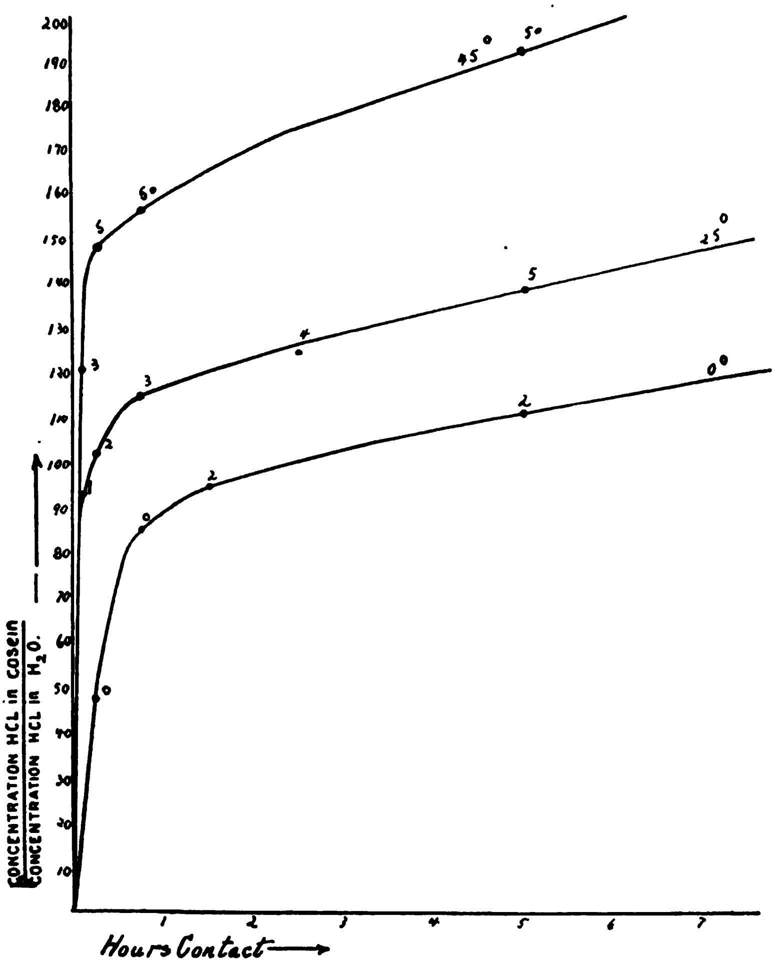

FIG. 12.—Effect of temperature on action of $\frac{N}{125}$ HCl on casein. The numbers 0, 1, 2, etc., represent relative degrees of solution of casein. (See p. 228.)

(1) Increase of temperature increases the rate at which equilibrium is approached. Thus, 25° and 45° C. curves rise more rapidly than those for 0° C.

(2) Increase of temperature increases the final amount of hydrochloric acid that disappears as free acid, *when there is marked solution of casein* due to the higher temperature, as shown by curves for 45° C. in Figs. 9-12 and for both 25° and 45° C. in Fig. 12. The soluble acid-casein apparently contains a larger proportion of hydrochloric acid than the undissolved casein, which would have the effect of raising the curve when the soluble form occurs. Our observation has been that solution of casein, whether resulting from increase of temperature, concentration of acid or length of contact with acid, is accompanied by fixation of more acid than is taken up when no solution occurs.

(3) When rise in temperature does not result in solution of proteid, it apparently decreases the amount of acid fixed. This may be seen by comparing the value expressed in Fig. 8 (A and B), which indicates a value of 97 to 100 for the ratio of acid in casein to acid in water at equilibrium at 25° C., with the results in Table VIII, which indicate a value of 147 for the ratio at 0° C. The same conclusion is shown by comparing the 25° and 0° C. curves of Figs. 9, 10 and 11, which express results obtained with acids sufficiently dillute to avoid very marked solution of proteid even at 25° C. The 25° curves rise more rapidly at first than do those for 0°, because the higher temperature increases the rate at which they approach equilibrium. They soon approach a horizontal position, however, and after 2½ to 4 hours cross the 0° curves, evidently inclining toward lower equilibrium values. With N-125 acid, however, the concentration is sufficient to dissolve decided amounts of proteid within a few hours at 25° C. Consequently, we should expect the 25° curve as well as that for 45° in Fig. 12 to be abnormally high, which is the case.

It was our purpose to study the effect of temperature upon equilibrium under conditions such that solution of proteid would be more completely avoided than at the temperatures used in the experiments given above, using only the most dilute solutions, and hastening equilibrium by constant agitation in order to produce more uniform conditions, which would show in more regular curves.

The time at our disposal for the work on casein, however, did not allow us to carry out these desired details, but the results obtained appear to be sufficiently decisive and uniform to justify the conclusions drawn.

ACTION OF SULPHURIC ACID UPON CASEIN WITHOUT SOLUTION.

The study of sulphuric acid was similar to that of hydrochloric, except that the temperature effect was not investigated in the case of sulphuric, while somewhat more attention was paid to the reversible character of the reaction. Because of the slighter solvent action of sulphuric acid, the experiments should be performed at room temperature. Agitation of the reacting mixtures was constant in all experiments.

TABLE XIV.— SHOWING AMOUNTS OF SULPHURIC ACID TAKEN UP BY CASEIN FROM N–125 SOLUTION AT 25°C.

(Proportions: 100 cc. of acid for 1 gram of casein.)

Duration of contact.	Concentration of acid in water (=cc. N–1000 acid in 1 cc. solution).	Concentration of acid in casein (=cc. N–1000 acid in 1 gm. casein).	Percentage of acid in original solution taken up by casein.	Ratio of conc'n acid in casein to conc'n acid in water.	Degree of solution of casein.
0	8.000	0	0	0	......
5 min.	3.490	451.0	56.4	129.2	0
45 min.	2.022	597.8	74.7	295.6	2
3 hrs.	1.971	602.9	75.4	305.9	3
6 hrs.	1.958	604.2	75.5	308.4	4

TABLE XV.— SHOWING AMOUNTS OF SULPHURIC ACID TAKEN UP BY CASEIN FROM N–500 SOLUTION AT 25°C.

(Proportions: 200 cc. acid for 1 gram of casein.)

Duration of contact.	Concentration of acid in water (=cc. N–1000 acid in 1 cc. solution).	Concentration of acid in casein (=cc. N–1000 acid in 1 gm. casein).	Percentage of acid in original solution taken up by casein.	Ratio of conc'n acid in casein to conc'n acid in water.	Degree of solution of casein.
0	2.015	0	0	0	......
15 min.	0.515	300.0	74.4	582	0
45 min.	0.495	304.0	75.4	614	1
3 hrs.	0.493	304.4	75.5	618	1
6 hrs.	0.489	305.2	75.7	624	2
12 hrs.	0.491	304.8	75.6	622	2

The data in Tables XIV and XV are summarized as follows:

(1) Casein takes up sulphuric acid from dilute solutions more quickly than it does hydrochloric acid, the maximum amount of acid being taken up in little more than 45 minutes (Table XV) when solution of proteid does not set in.

(2) The amount of sulphuric taken up by casein, the proportions of acid and casein being the same, is greater than in the case of hydrochloric acid.

(3) The equilibrium ratio is not even approximately a constant, but increases rapidly with the dilution of acid employed. This behavior is in accord with that usually observed in adsorption.

Extraction of sulphuric acid taken up by casein.—The work was carried out in detail in the manner described on p. 240. The essential results, properly corrected, are given without the details of correction in the table following:

TABLE XVI.— SHOWING AMOUNTS OF SULPHURIC ACID EXTRACTED FROM CASEIN BY WATER.

No. of Experiment.	Duration of contract between acid-casein and water.	Cc. N-1000 acid in acid-casein before extraction.	Cc. N-1000 acid extracted from acid-casein.	Cc. N-1000 acid left in casein.	Concentration of acid in water.	Ratio of conc'n acid in casein, to conc'n acid in water.
	0	301.4	0	301.4	(.0175)	(17,220)
1	1 min.	301.4	32.9	268.5	.3291	816
2	15 min.	301.2	35.0	266.2	.3489	764
3	1 hr.	301.0	37.1	263.9	.3747	704
4	2½ hrs.	301.2	38.7	262.5	.3775	695
5	5 hrs.	299.6	37.4	262.2	.3704	708

As would be expected from the high value of the ratio of acid in casein to acid in water (Table XV), the results indicate that sulphuric acid is not so completely extracted from casein by water as is hydrochloric acid. About 80 per ct. of the acid that can be extracted, however, by one portion of water is extracted in one minute. After 5 hours of constant agitation with the same amount of water, only about 12 per ct. of the acid that had been taken up by the casein was removed, and 1 gram of casein then contained about 700 times as much acid as did each cc. of the surrounding solution.

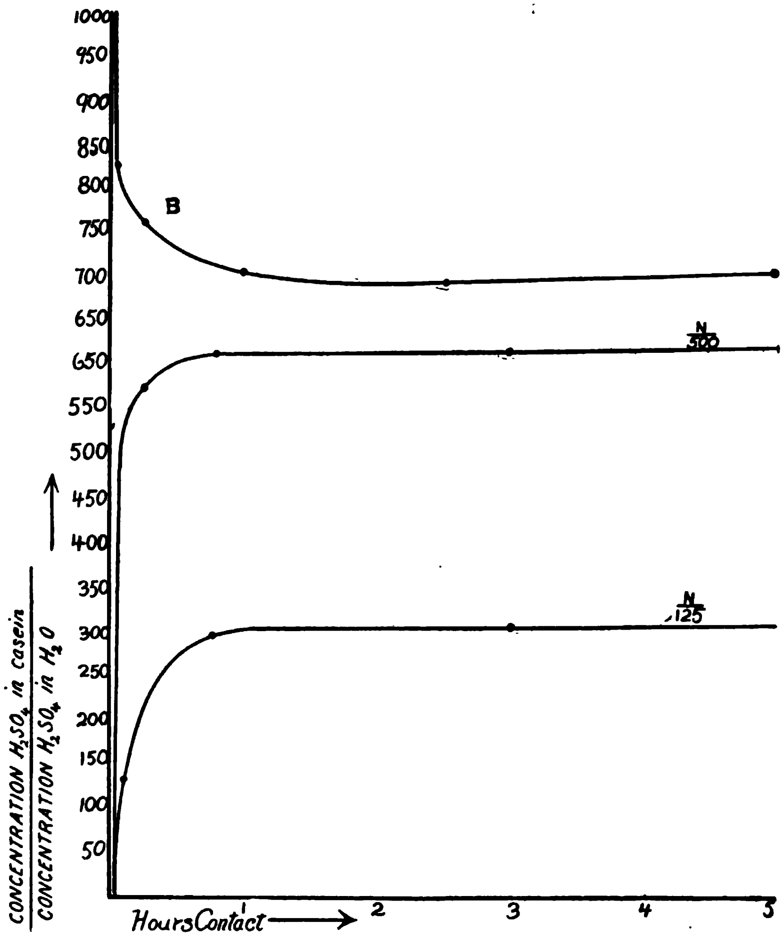

FIG. 13.—Upper curve (B) represents action of water in extracting sulphuric acid from casein that had taken it up. (Table XVI.) Two lower curves represent action of casein in taking up acid from $\frac{N}{500}$ and $\frac{N}{125}$ solutions. (Tables XIV, XV.)

The tenacity with which sulphuric acid is held by casein is interesting as explaning the difficulty which Hammarsten[1] found in trying to remove sulphuric acid from casein by rubbing in a mortar with successive portions of water. Van Slyke and Hart[2] found that it required 80 or 90 triturations with successive portions of fresh water to remove completely the sulphuric acid from casein. It also appears, from the readiness with which a given amount of water extracts the maximum amount of acid by simply shaking with the acid-casein, that a few minutes of agitation with each of a number of successive portions of pure water should remove the acid as well as trituration.

From the varying levels approached by the curves of Fig. 13, it is apparent that the equilibrium ratio of acid in 1 gram casein to acid in 1 cc. water is, as already mentioned above, not a constant, even within the limits of concentration tested, but increases with the dilution. In order to follow the variation of the ratio, the following experiment was performed:

.4795 g. of casein was shaken for two and one-half hours with 100 cc. of N-250 $H_2 SO_4$. As indicated by Table XV and the curves, this time is sufficient for equilibrium to become practically complete, and not long enough to result in appreciable solution of proteid. The suspension was allowed to settle until the supernatant solution was perfectly clear, then 50 cc. of the latter drawn off with a pipette and replaced by an equal volume of conductivity water. The mixture was then shaken two hours and 50 cc. of the solution again replaced by conductivity water; and this process was repeated twice more. The 50 cc. portions drawn off were first tested for conductivity, then titrated with N-100 KOH. In no case was a precipitate noticed on titrating, and the titration results, considering the dilution of the solutions, agree throughout satisfactorily with those obtained by conductivity. Evidently no appreciable solution of proteid occurred.

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[1] *Jahresber. Tier-Chem.*, 7:160. 1877.
[2] N. Y. Agrl. Expt. Sta. Bull. No. 261, p. 14.

TABLE XVII.— SHOWING EFFECT OF CONCENTRATION OF SULPHURIC ACID UPON VALUE OF EQUILIBRIUM RATIO $\frac{\textit{con. } H_2SO_4 \textit{ in casein}}{\textit{con. } H_2SO_4 \textit{ in water.}}$

No.	DESCRIPTION.	Concentration of acid in water (=cc. N–1000 acid in 1 cc. solution) by conductivity.	Concentration of acid in water by titration.	Concentration of acid in casein (=cc. N–1000 acid in 1 g. casein).	Ratio of conc'n acid in casein to conc'n acid in water.
1	Acid as used in experiment.........	4.090	4.08	0	0
2	Acid after shaking 100 c.c. with .4795 gm. casein......................	1.547	1.60	509.4	329.4
3	Solution obtained by replacing 50 c.c. of No. 2 with water and shaking until equilibrium was restored....	1.083	1.10	445.0	411.0
4	Solution obtained by replacing 50 c.c. of No. 3 with water and skaking until equilibrium was restored....	0.828	0.82	385.4	465.5
5	Solution obtained by replacing 50 c.c. of No. 4 with water and shaking until equilibrium was restored....	0.667	0.64	332.7	498.7

It is evident that the value of the ratio varies inversely as the concentration of the acid; it increases with the dilution. This increase is similar to that observed in most cases of adsorption phenomena and, moreover, occurs in accordance with the exponential formula, $\beta = \frac{C_1^p}{C_2}$, found empirically to hold in a large proportion of adsorptions, that are reported,[1] in which β = a constant; C_1 = amount of solute adsorbed per unit mass of adsorbent (= concentration of sulphuric acid in casein); C_2 = concentration of solute in solution in contact with adsorbent (= concentration of sulphuric acid in water); p, the exponent of c, is a constant, dependent like β upon the substances and conditions; p = 1.95 in the present case. In the following table are arranged all the equilibrium results recorded in the foregoing tables. They show the regular increase of the ratio with the dilution of sulphuric acid and the approximate constancy of β, independant of the manner in which equilibrium was obtained.

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[1] Schmidt. *Ztschr. Phys. Chem.*, 15:56. 1894; Walker and Appleyard. *Jour. Chem. Soc.* 69:1334. 1896; Freundlich. *Ztschr. Phys. Chem.*, 57:385. 1906.

TABLE XVIII.— SHOWING EFFECT OF DILUTION OF SULPHURIC ACID UPON EQUILIBRIUM RATIO $\frac{C_1}{C_2}$.

No.	METHOD OF OBTAINING EQUILIBRIUM.	Tables from which results are taken.	Dilution (Equiv. volume) of acid at equilibrium.	$\frac{C_1}{C_2}$ (= $\frac{\text{Conc'n acid in casein}}{\text{Conc'n acid in water.}}$)	$\beta \times 10^{-4}$ ($\beta = \frac{C_1^{1.99}}{C_2}$)
1	Shaking N–125 acid with casein.....	XIV	510.6	308.4	13.5
2	Shaking N–250 acid with casein.....	XVII	646.5	329.7	12.3
3	Replacing with water half of solution 2 in contact with acid-casein and shaking........................	XVII	923.4	411.0	13.4
4	Replacing with water half of solution 3 in contact with acid-casein and shaking........................	XVII	1205.	465.5	13.3
5	Replacing with water half of solution 4 in contact with acid-casein and shaking........................	XVII	1499.	498.7	12.4
6	Shaking N–500 acid with casein.....	XV	2053.	622.0	14.1
7	Shak'ng acid-casein with pure water..	XVI	2703.	695.0	13.7

ACTION OF LACTIC ACID UPON CASEIN WITHOUT SOLUTION.

The work with lactic acid covers the concentrations, N-125, N-500, and N-1000. We used 100 cc. of each solution for 1 gram of casein. The method of experiment is described in detail on pp. 210–221. The results of the work are presented in Table XIX.

TABLE XIX.— SHOWING AMOUNTS OF LACTIC ACID TAKEN UP BY CASEIN AT 0° C.

Proportion and approximate normality of acid used.	Duration of contact.	Concentration of acid in water (=cc. N – 1000 acid in 1 cc. solution).	Concentration of acid in casein (=cc. N – 1000 acid in 1 gm. casein).	Percentage of lactic acid in original solution taken up by casein.	Ratio of conc'n acid in casein to conc'n acid in water.	Degree of solution of casein.
N–1000	0	.933	0	0	0	......
100 c. c.	5 min.	.843	9.0	9.7	10.7	0
for 1 gram.	45 min.	.744	18.9	20.2	25.5	0
of	1½ hrs.	.699	23.4	25.1	33.5	0
casein.	6 hrs.	.586	34.7	37.2	59.2	1
	0	.944	0	0	0	......
	12 hrs.	.532	41.2	43.6	77.5	1
	24 hrs.	.520	42.4	44.9	82.0	1
	48 hrs.	.516	42.8	45.3	83.0	2

TABLE XIX.— SHOWING AMOUNTS OF LACTIC ACID TAKEN UP BY CASEIN AT 0° C.— (*Continued*).

Proportion and approximate normality of acid used.	Duration of contract.	Concentration of acid in water (=cc. N-1000 acid in 1 cc. solution).	Concentration of acid in casein (=cc. N-1000 acid in 1 gm. casein).	Percentage of lactic acid in original solution taken up by casein.	Ratio of conc'n acid in casein to conc'n acid in water.	Degree of solution of casein.
N-500	0	1.922	0	0	0	......
100 c. c.	5 min.	1.855	6.7	3.5	3.6	0
for	45 min.	1.611	31.1	16.8	19.3	0
1 gram	1½ hrs.	1.547	37.5	19.5	24.2	0
of	6 hrs.	1.294	62.8	32.6	48.5	1
casein.	0	1.908	0	0	0	......
	12 hrs.	1.095	81.3	42.6	74.2	1
	24 hrs.	1.069	83.9	44.0	78.5	2
	48 hrs.	1.062	84.6	44.3	79.7	2
N-125	0	8.048	0	0	0	......
100 c. c.	5 min.	7.073	97.5	12.1	13.8	1
for	45 min.	6.723	132.5	16.5	19.7	1
1 gram	1½ min.	6.040	200.8	25.0	33.2	2
of	6 hrs.	5.140	290.8	36.1	56.6	3
casein.	10 hrs.	4.841	320.7	40.0	66.2	4
	24 hrs.	4.652	339.6	42.2	73.0	4
	30 hrs.	4.580	346.8	43.0	75.7	5

The results embodied in the preceding table may be summarized as follows:

(1) The amount of lactic acid taken up by casein varies with the time of contact and the concentration of the acid in which the action takes place.

(2) The amount of lactic acid taken up at equilibrium by 1 gram of casein varies nearly in proportion to the final concentration of the free acid surrounding the casein, as we have found to be true in case of hydrochloric acid. The amount of lactic acid taken up under similar conditions by 1 gram of casein is less than in the case of hydrochloric acid.

(3) In the case of lactic acid, the ratio obtained by dividing the amount of acid in 1 gram of casein by the amount of acid in 1 cc. of the surrounding solution is 75.7 to 83, within the concentrations tested, when equilibruim is approached, which occurs at 0° C. in 24 hours, while in the case of hydrochloric acid the ratio is about 147.

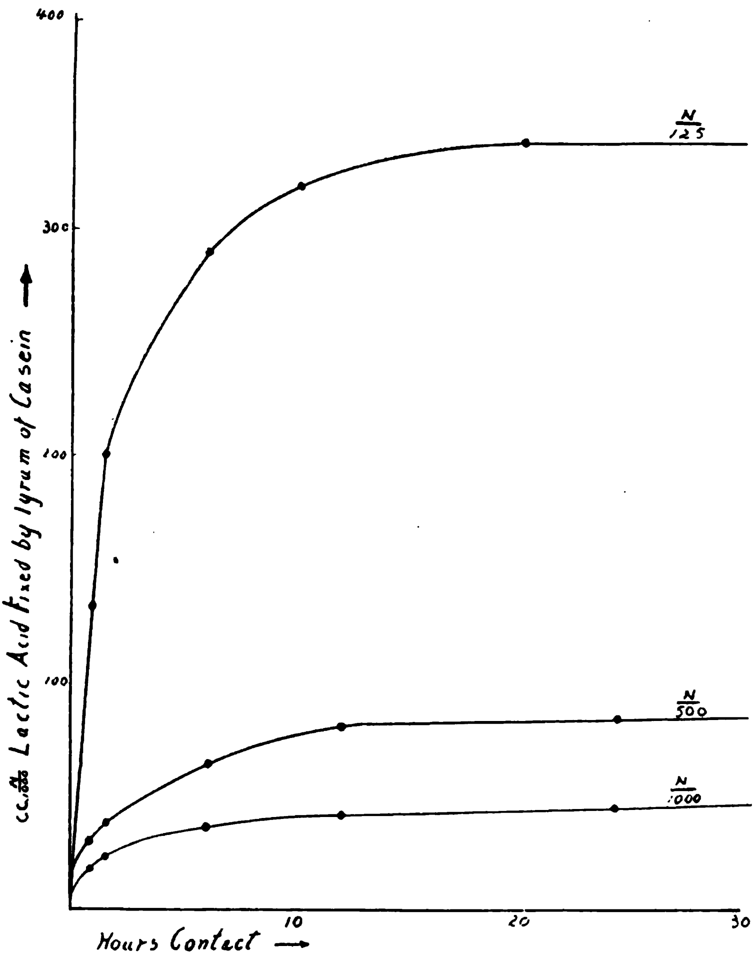

FIG. 14.—Showing amounts of lactic acid taken up at 0° by casein from solutions of different concentrations, and rate of reaction.

ACTION OF ACETIC ACID UPON CASEIN WITHOUT SOLUTION.

The work with acetic acid includes experiments at 0° C. with N-500 and N-1000 solutions and at 25° C. with N-125 acid. The results are tabulated below.

TABLE XX.— SHOWING AMOUNTS OF ACETIC ACID TAKEN UP BY CASEIN.

Proportion and approximate normality of acid used.	Temperature.	Duration of contact.	Concentration of acid in water (=cc. N-1000 acid in 1 cc. solution).	Concentration of acid in casein (=cc. N-1000 acid in 1 gm. casein).	Precentage of lactic acid in original solution taken up by casein.	Ratio of conc'n acid in casein to conc'n acid in water.	Degree of solution of casein.
N-500	0° C.	0	1.916	0	0	0	....
100 c. c.	0° C.	6 hrs.	1.430	48.6	25.4	34.0	0
for	0° C.	12 hrs.	1.433	48.3	25.2	33.7	0
1 gram of casein.	0° C.	24 hrs.	1.420	49.6	25.9	34.9	0
N-1000	0° C.	0	.990	0	0	0	....
100 c. c.	0° C.	6 hrs.	.749	24.1	24.3	32.2	0
for	0° C.	12 hrs	*.774	21.6	21.9	27.9	0
1 gram of casein.	0° C.	24 hrs.	.731	25.9	26.2	36.2	0
N-125	25° C.	0	8.000	0	0	0	....
100 c. c.	25° C.	5 min.	6.805	119.5	14.9	17.6	0
for	25° C.	45 min.	6.214	178.6	22.3	28.7	1
1 gram of	25° C.	3 hrs.	5.923	207.7	26.0	35.1	1
casein.	25° C.	6 hrs.	5.677	232.3	29.0	40.9	2

Briefly summarized, the results embodied in the preceding table indicate that,—

(1) The action of acetic acid with casein is in a general way similar to that of the other acids previously considered.

(2) Acetic acid is taken up by casein in considerably smaller amounts than are the other acids, conditions being uniform.

(3) A comparison of the action of casein with the acids studied is graphically shown in Fig. 15. The curves represent results obtained with N-500 solution in each case at 0° C.

NON-ACTION OF CASEIN ON DILUTE SOLUTIONS OF NEUTRAL SALTS.

In order to determine the effect of displacing the H^+ ion from solution, half-gram samples of casein were shaken with 50 cc. portions of the pure N-50 KCl solution used for standardizing the conductivity cells, the duration of shaking varying from 5 minutes to

*Evidently contamination of filtrate caused abnormally high result. Low conductivity of acetic acid renders dilute solutions very susceptible to change in conductivity by slight contamination.

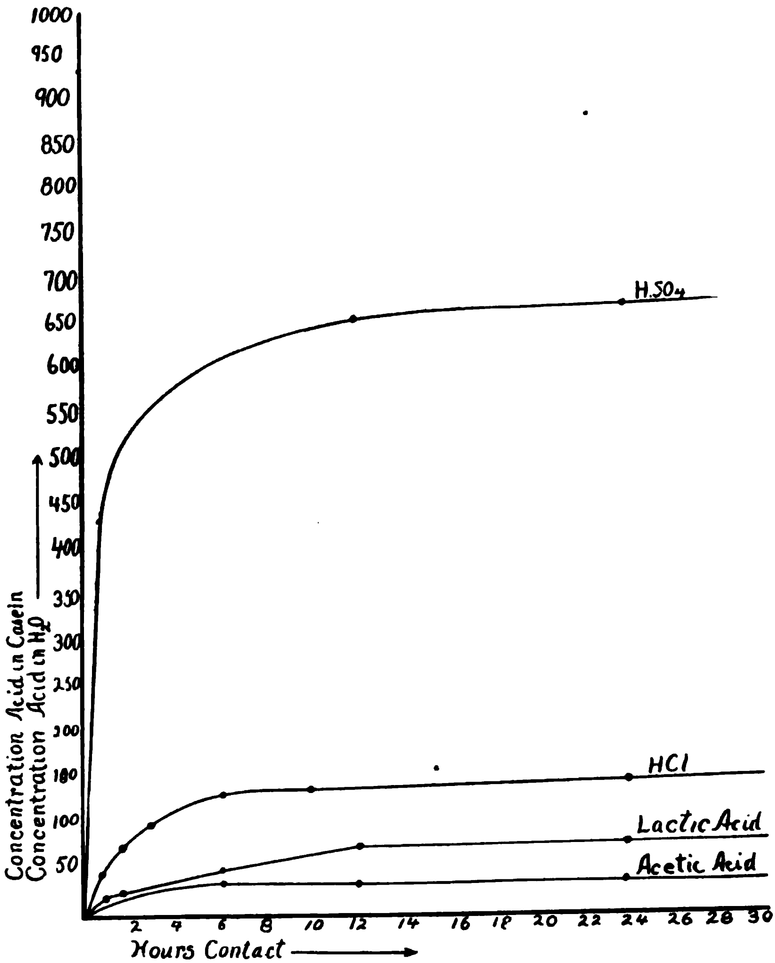

FIG. 15.—Comparison of different acids of $\frac{N}{600}$ concentration in respect to their action in being taken up by casein at 0°.

28 hours. In no case was change in conductivity observed. In the case of N-125 $MgSO_4$ solution similarly treated, there was a decrease of only a few tenths of a per ct. in conductivity. From these experiments, it is apparent that the H^+ ion is the factor in solution on which depends the fixation of the large amounts of electrolyte previously determined in the experiments with the mineral acids.

DISCUSSION OF RESULTS.

In the foregoing pages, it has been shown (1) that when casein and a dilute acid, as, for example, hydrochloric acid, are shaken together, the final amount of acid taken up by a gram of casein without solution of the proteid is not constant but varies continuously with the concentration of the surrounding acid solution; (2) that, however small the amount of acid used, it is never completely taken up; (3) that the amount of acid taken up varies also with the temperature; and (4) that the acid passes as readily from the casein into the surrounding solution as from the solution into the casein, moving either way according to the change required to establish the equilibrium ratio, amount of acid in 1 gram of casein divided by the amount of acid in 1 cc. of surrounding solution, as shown in the cases of hydrochloric and sulphuric acids. It is evident that no acid-casein compound of constant composition is formed. Three different explanations may be offered to account for the facts observed:

(1) The reaction may be regarded as one of adsorption, the insoluble acid-casein being what van Bemmelen calls an adsorption compound.

(2) Applying Witte's explanation of the fixing by fibers of substantive dyes, the reaction may be one of solution, the acid dividing itself between casein and water as resorcinol divides itself between ether and water, according to its solubility in each.

(3) The insoluble acid-casein may be regarded as a hydrolyzible salt, its inconstant composition being due to hydrolysis, which varies with the temperature and concentration of the acid.

We will consider each of these hypotheses in their relation to the facts that have been developed.

IS THE REACTION ONE OF ADSORPTION?

By adsorption is meant the process whereby a solid substance A in contact with a solution of a dissolved substance B concentrates B upon its surface, withdrawing a portion of B from solution without forming with it a definite chemical compound.

In regard to the characteristics of adsorption reactions, we quote the five characteristic points given by van Bemmelen for reactions of this class:[1]

"(1) The adsorbed amounts stand in no equivalent proportions to the adsorbing mass.

"(2) The composition varies with the structure of the adsorbing substance and with all modifications which the latter undergoes by reason of its method of preparation, age, heat or action of other substances.

"(3) The composition varies with the temperature.

"(4) Likewise with the concentration of the solution, in case substances are adsorbed from their solutions; and the composition varies in such manner that the adsorption factor k in the formula $\frac{c_1}{c_2} = F(k)$ is not constant, but is dependent upon the concentration of the solution according to a function that we do not understand. In general, however, c_1 increases more slowly than c_2" ($\frac{c_1}{c_2}$ decreases as concentration increases).

c_1 = amount of solute adsorbed per unit mass of adsorbent.

c_2 = concentration of solute in solution.

F = unknown function.

In another article[2] however, van Bemmelen says: "When the adsorptive power is small and the solution not concentrated, then, between certain limits of concentration, $\frac{c_1}{c_2}$ is nearly constant."

In regard to the variation of $\frac{c_1}{c_2}$, while, as van Bemmelen states, an entirely general and accurate formula is unknown, the relation in a large proportion of adsorptions, can be expressed

[1] *Ztschr. Anorgan. Chem.*, 36:381. 1903.
[2] *Ztschr. Phys. Chem.*, 18:33. 1895.

with a fair degree of approximation by the equation, $\beta = \frac{c_1{}^p}{c_2}$, β and p being constants dependent in value upon the active substances and the conditions. The formula has been found to hold by Freundlich, Walker and Appleyard, and Schmidt. (loc. cit.) In the experiments of Schmidt, p was found to vary from 2 to 10, while in those of Freundlich (loc. cit. p. 396) p did not vary greatly from 2 in most cases. When p becomes unity, the formula applies to the case in which $\frac{c_1}{c_2}$ = constant.

"(5) The velocity with which the formation of an adsorption compound occurs decreases continually as more substance is adsorbed and the adsorption approaches equilibrium." In another article van Bemmelen[1] says: "The adsorption begins with great speed and decreases continually as more substance is adsorbed and equilibrium is approached. With constant shaking, the latter is usually reached in one to three hours."

To the above we may add the two points following:

(6) The reaction approaches a true equilibrium, which can be approach from either side, as stated by Ostwald,[2] and as shown by the work of Freundlich,[3] and laso by Walker and Appleyard.

(7) Ostwald[4] expresses graphically as follows the characteristic relation between the concentration of the solution and amount of solute adsorbed. Using rectangular coordinates, if one plots dilutions of the solution as ordinates and amounts of solute adsorbed as abscissae, the resulting curve will be nearly a hyperbola.

Of the above, the first and most important point corresponds entirely with the facts observed in the reaction between casein and acids. There are no definite combining proportions.

None of our data bears upon the second point, since the casein was all prepared and kept by one uniform method.

The third statement is in harmony with our results. In the cases tested, temperature was found to have a considerable influence upon the amount of acid fixed.

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[1] *Ztsch. anorg. Chem.*, 23:345. 1900.
[2] Lehrb. d. Allg. Chem. 2d Aufl. 1, 1903.
[3] Loc. cit. p. 389.
[4] Loc cit.

Regarding the fourth point, it was found that in all cases the fundamental principle was complied with: The amounts of acid taken up per gram of casein at equilibrium depend upon the final concentrations of the solutions. In the cases of hydrochloric, lactic, and acetic acid, $\frac{c_1}{c_2}\left(=\frac{\text{concentration acid in casein}}{\text{concentration acid in water}}\right)$ is nearly constant. This, acording to van Bemmelen, may occur when solutions are dilute and adsorptive power weak. While the adsorptive power, particularly in the case of hydrochloric acid, is not weak, the solutions were very dilute. In the case of sulphuric acid, where adsorption is much stronger, the ratio $\frac{c_1}{c_2}$ increases with the dilution, in accordance with the usual behavior of adsorptions, and the increase occurs in accordance with the exponential formula, $\beta=\frac{c_1^p}{c_2}$, which has been found to hold in a large proportion of adsorptions, p being 1.95 in this case (p. 255). If p be taken nearly equal to unity, the same formula holds for the other acids.

In velocity, the reaction, agreeing with van Bemmelen's fifth criterion, begins with great speed, and becomes slow as equilibrium is approached. Particularly when the mixtures of casein and acid are subjected to constant agitation so that the casein does not have to wait for acid to reach it by diffusion, the initial velocity was enormous, the curves being nearly parallel to the ordinate axis for some distance. Negative acceleration is, of course, observed in reactions in general as they approach equilibrium, so that no great force is to be attributed to this characteristic for the purpose of classifying the reaction, although the enormous initial velocity is not usually observed in intermolecular reactions requiring considerable time for completion. The great velocity with which acid is extracted by water from the insoluble acid-casein furnishes a marked contrast to the stability of the precipitated acid albumin of von Rohrer, an apparently true chemical compound, which could be washed with water without changing materially its acid content.

The fact that the equilibrium can be approached from both sides has been shown in the cases of both hydrochloric and sulphuric acids.

As shown in Fig. 20, the curves obtained in the manner indicated by Ostwald are similar to the hyperbola.

From the foregoing considerations, it is evident that the reaction between casein and dilute-acids shows the characteristics of adsorption phenomena.

IS THE REACTION A CASE OF SOLUTION OF ACID IN CASEIN?

Most of the qualitative characteristics of the reaction, such as the lack of definite combining proportions and the ability of the acid to divide itself according to a definite ratio between casein and water, are characteristics of the partition of a solute between two solvents, as well as of adsorption. The behavior of the ratio $\frac{C_1}{C_2}$ in the case in question particularly when sulphuric acid is considered, does not, however, correspond to the conditions of distribution in such cases. To quote Walker[1] in regard to the law of distribution in solution: "If the molecular weight of the substance in one solvent is n times as great as its molecular weight in the other solvent, then, when equilibrium is attained, the nth root of the concentration in the first solvent will bear a constant ratio to the concentration in the second solvent." According to this, the molecular weight of hydrochloric acid would have to be regarded as the same in water that it is in its hypothetical solution in casein, in order that the ratio of concentration of acid in casein to concentration of acid water should be constant. As is shown, however, by the freezing point, osmotic pressure and electrical conductivity of hydrochloric acid solutions, the hydrochloric acid molecule is almost completely dissociated in water at the concentrations employed. An equal degree of dissociation is required by the laws of solution for the hydrochloric acid in the casein, where it is from 100 to 150 times as concentrated as in the water. This would require us to regard casein as a solvent having a remarkable dissociating effect, far surpassing that of water, which is very improbable. In the case of the reaction with sulphuric acid in which the ratio decreases as concentration of acid in water increases, the laws of solution require a much smaller molecular weight for the sulphuric acid in casein than that of sulphuric acid in water solution, which is clearly an impossibility. From the foregoing considerations, it is evident that the hypothesis of solution does not apply to the action under consideration.

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[1] *Jour. Chem. Soc.* [*London*], *Trans.*, 69:1335. 1896.

IS THE ACID-CASEIN SOLID A HYDROLIZIBLE SALT?

In case the insoluble acid-casein were a hydrolyzible salt of an acid, as hydrochloric acid, casein acting as a weak base, we should observe the same qualitative characteristics as those noted, viz., the dependence of the amount of acid taken up by casein upon the concentration used and upon the temperature, and a loss of acid when the insoluble acid-casein is shaken with pure water. We should, however, expect somewhat more hydrochloric than sulphuric acid, reckoned in equivalents, to be taken from solution of equal concentrations, since hydrochloric acid is somewhat the stronger acid. Instead, the amount of sulphuric acid taken up is much the greater. Furthermore, according to the law of mass action and the behavior of chemical reactions of this class, equilibrium would always be reached when the concentration of the free acid had been reduced to a certain constant value, the amount of acid held by casein being no factor in the equilibrium so long as all the basic valences of the latter were not neutralized. According to the law of mass action, if we regard the insoluble acid-casein as a salt of an acid, say hydrochloric acid for example, hydrolyzing in accordance with the hypothetical equation,

$$\underset{\text{(acid-casein)}}{\text{Casein Cl y}} + \text{y } H_2O \rightleftarrows \underset{\text{(free casein)}}{\text{Casein (OH)y}} + \text{y HCl},$$

equilibrium must be reached when

$$\frac{C^{y}_{HCl} \times C_{\text{Casein (OH) y}}}{C^{y}_{H_2O} \times C_{\text{Casein Cl y}}} = K_t,$$

in which C_{HCl} = concentration of HCl; $C_{\text{Casein (OH) y}}$ = concentration of free casein, etc.; y = basic valence of casein; K_t = a constant dependent on temperature. The hydrochloric acid is the only reagent of variable concentration. Consequently [1] the equation simplifies to $C_{HCl} = K_t$.

The accuracy of this form of equation for reactions involving only one substance of variable concentration has been repeatedly proved by well-known reactions. In the decomposition of $CaCO_3$ by heat, $C_{CO_2} = K_t$. In the reaction by which ammonia and

[1] "Only gaseous and dissolved substances have varying concentrations." (Ostwald Principles of Inorganic Chemistry. Translation by Findlay, p. 327, 1902.)

$CaCl_2$ combine, the pressure (concentration) of ammonia at equilibrium depends only on the temperature. The same is true of the reaction between PbO and NH_4Cl, in which ammonia is formed.[1]

As examples in which the reaction is hydrolysis and therefore especially comparable to the hypothetical hydrolysis of insoluble acid-casein, the hydrolyses of mercurous sulphate and of the picrate of diphenylamine may be noted. The first reaction was studied by Gouy[2] and by Hulett.[3] It occurs in accordance with the equation.

$$3\ Hg_2SO_4 + 2\ H_2O \rightleftharpoons [Hg\ (OH)]_2\ (Hg_2SO_4) + 2\ HgHSO_4.$$

The $HgHSO_4$ is relatively the only soluble substance and consequently the only one of varying concentration. Equilibrium is reached when $C_{HgHSO_4} =$ constant, this constant concentration at 25° C. being 0.00225 molecular weights in grams per liter. When Hg_2SO_4, or a mixture of it with the basic salt, was shaken with water, hydrolysis always proceeded until the concentration of the $HgHSO_4$ reached this value, and no further hydrolysis occurred unless the mixture of salts was treated with fresh water, when the process again went to the same limit, and it could be repeated until all the Hg_2SO_4 was changed. Hulett treated a portion of Hg_2SO_4 thus with 43 successive portions of water and found at the end of each treatment (of 12 hours) the same concentration of $HgHSO_4$ in solution. The forty-third treatment exhausted the Hg_2SO_4 and further treatment had no effect except to dissolve traces of the basic salt.

The picrate of diphenylamine, like all salts of this base,[4] is hydrolyzed by contact with water, with formation of picric acid and diphenylamine. Both diphenylamine and its picrate are, like casein and acid-casein, practically insoluble. The picric acid is, therefore, the only reagent of variable concentration. Walker[5] found that picric acid (saturated solution) placed in contact with varying excess portions of diphenylamine always combined with it until the concentration of the acid was reduced to 13.8 mgs. per cc. If picric

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[1] Isambert. *Compt. Rend. Acad. Sci.* [*Paris*], 102:1313. 1886.

[2] *Compt. Rend. Acad. Sci.* [*Paris*], 130:1399. 1900.

[3] *Ztschr. Phys. Chem.*, 49:491. 1904.

[4] Meyer and Jacobson. Lehrbuch der Organishe Chemie, II (1) p. 177. 1902.

[5] *Jour. Chem. Soc.* [London], *Trans.*, 69:1341. 1896.

acid of less concentration than 13.8 mgs. per cc. was placed in contact with diphenylamine, *no* combination occurred.

From the preceding discussion of adsorption reactions and of hydrolysis in which, of the reacting substances, only the acid has variable concentration (that is, is soluble), it is evident that the two kinds of reactions are represented by curves which characteristic differences as shown in Figs. 16 and 17.

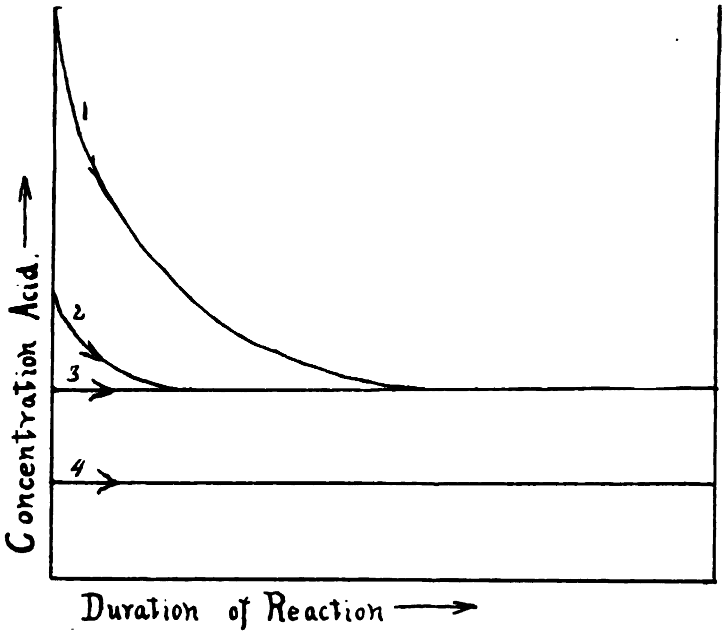

FIG. 16.—Typical curves for combination of acid to form hydrolyzible salt, both base and salt being insoluble.

The four curves in each of the diagrams represent the theoretical effect of contact with an excess of insoluble base (Fig. 16) and with an adsorbent mass (Fig. 17), respectively, upon portions of acid of varying concentration, the conditions used, other than concentration of acid, being the same for the four cases represented in each figure.

The diagrammatic curves of Fig. 16 signify that,—

(1) When an insoluble base forming an insoluble hydrolyzible salt is treated with acid of the equilibrium concentration (curve 3), as, for example, 13.8 mgs. per cc. in the case of picric acid and diphenylamine, none of the acid is combined, so that its concentration remains constant.

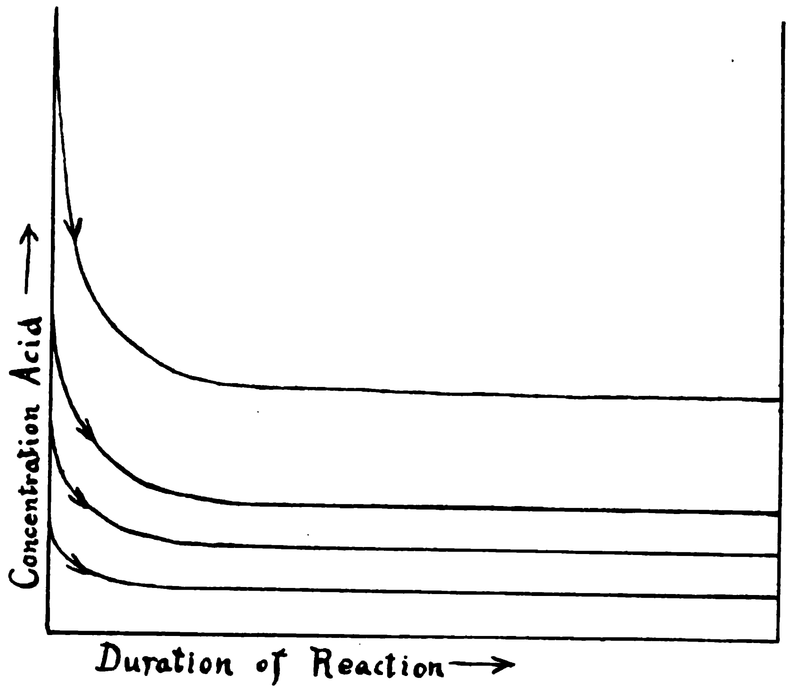

FIG. 17.—Typical curves for adsorption.

(2) Likewise, when the initial concentration is less than that required for equilibrium, none is combined (curve 4).

(3) When the initial concentration is greater than that required for equilibrium (curves 1 and 2), acid is combined until the concentration of free acid is reduced to the equilibrium value, which is the same, whatever the initial concentration of the acid,

The curves of Fig. 17 signify that,—

(1) When an acid or other substance is adsorbed from solution, the initial concentration, however small, is always reduced by contact with the adsorbent.

(2) The equilibrium concentration varies wih initial concentration in each case. There is no equilibrium constant for the concentration.

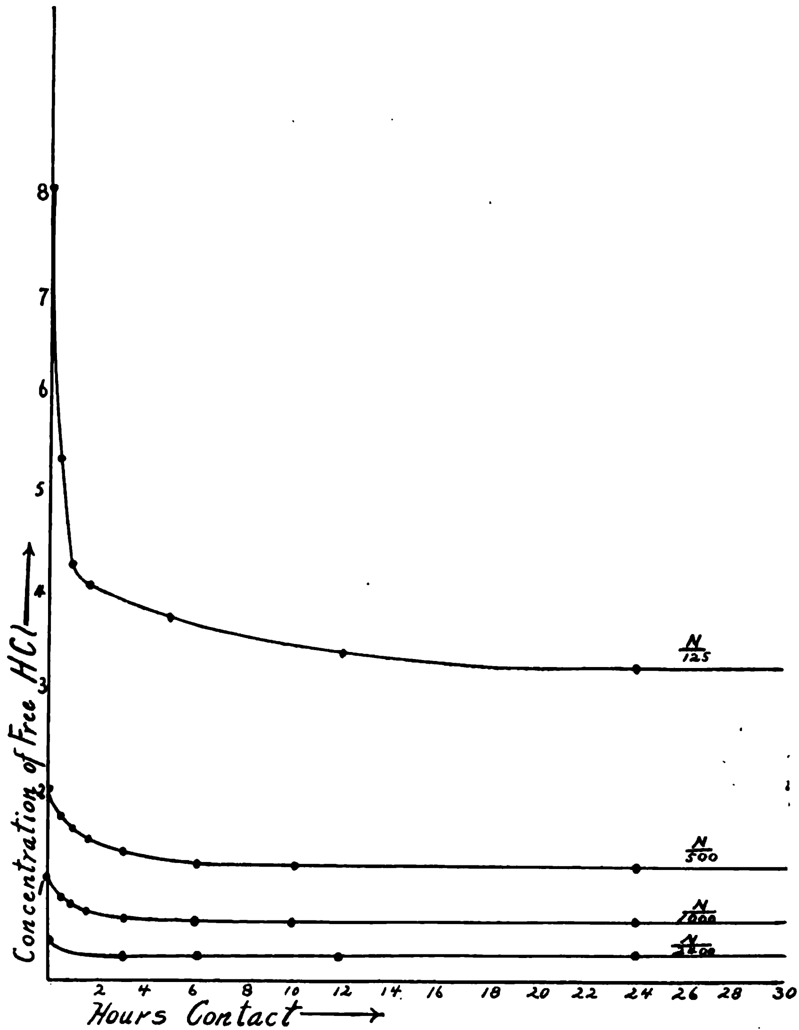

FIG. 18.—Showing decrease of concentration of free hydrochloric acid resulting from action of casein in taking up acid. (Table VIII, column 3.) Comparison with Figs. 16 and 17 shows that the curves are characteristic of adsorption.

The curves of Fig. 18 express results obtained with four initial concentrations of hydrochloric acid, as given on p. 227, Table VIII, column 3. Similar curves are obtained by plotting the results tabulated for the other acids. The forms of the curves (compare with Figs. 16 and 17) show clearly that the reaction has the characteristics noted above for adsorption and does not fulfil the requirements of the formation of a hydrolyzible salt.

This fact is brought out even more strikingly by the application of Ostwald's graphic criterion for adsorption. According to this if, using equilibrium data, one plots dilutions of the solution as ordinates and amounts of solute adsorbed as abscissae, the characteristic curve for adsorption is similar to a hyperbola. In the case of formation of a hydrolyzible salt of the kind in question, the curve would be very different. For the combination of any acid at all, the dilution could not exceed that corresponding to the concentration constant. Nor, until the base is completely neutralized, can acid in contact with it at equilibrium be of less dilution than the constant, since the acid will continue to combine until that dilution is reached. Consequently, as more acid is added to a solution in contact with the base, the latter takes it up, keeping the dilution constant until the basic valences are all saturated, the curve expressing these conditions being a horizontal line. Further addition of acid simply decreases the dilution, since further combination is impossible, and the curve drops perpendicularly. The two types of curves are illustrated in Fig. 19. Curves 1 and 2 represent adsorptions following the equation $\beta = \frac{c_1{}^p}{c_2}$, in which p has the values 1 and 2 respectively. In the former case the curve is a true hyperbola. In the latter it represents the average relations observed by Freundlich in adsorption by charcoal. The rectilinear curve 3 represents the conditions in the formation of a solid salt, as described above. In Fig. 20 the results experimentally obtained with the various acids are graphically represented. Comparison with Fig. 19 shows that the reactions represented are adsorptions.

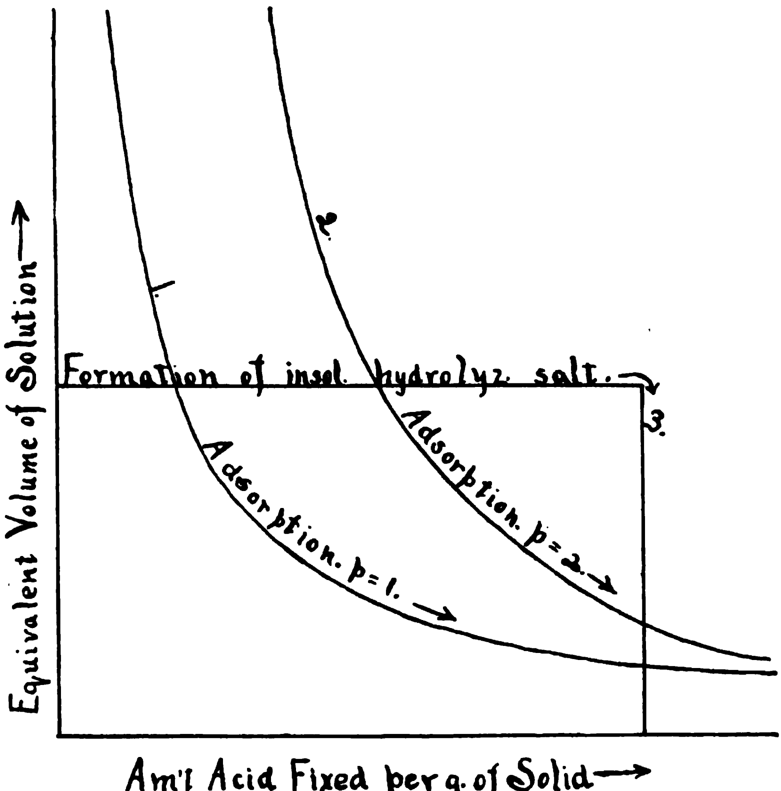

FIG. 19.—Typical curves contrasting relations in adsorption, with those in formation of an insoluble hydrolyzible salt from an insoluble base. The adsorption curves are plotted in accordance with the exponential formula $\beta = \frac{C_1 p}{C_2}$. Arrows above curves indicate direction of change caused by addition of acid.

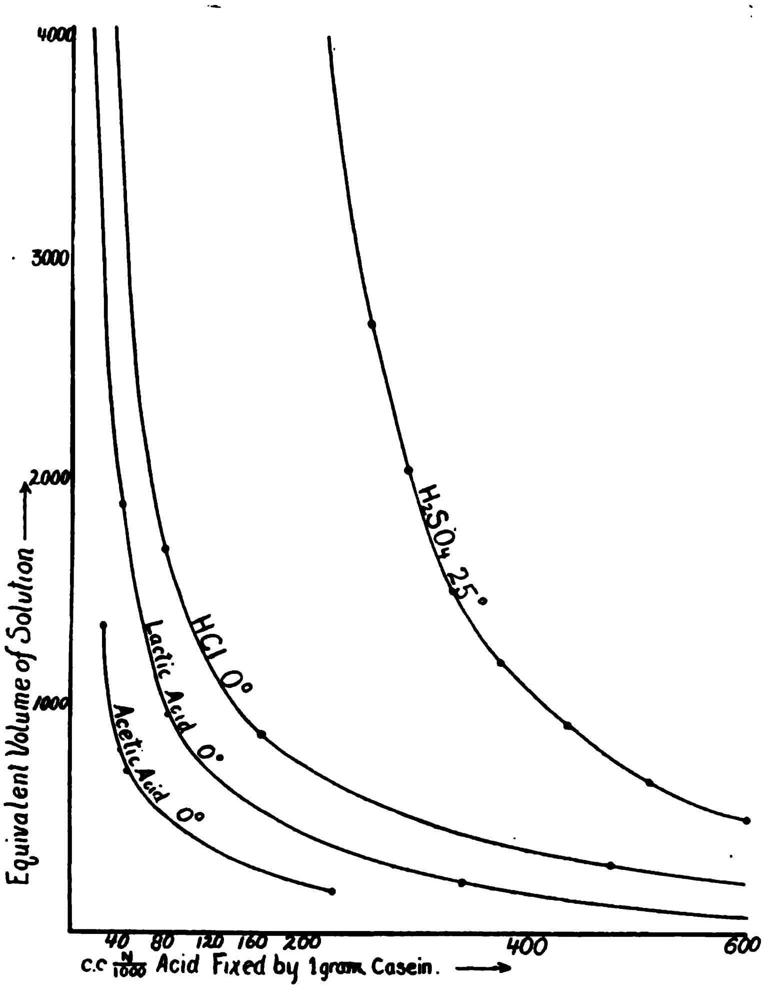

FIG. 20.— Curves express relation at equilibrium between dilution of various acids and amounts fixed by one gram of casein.

Comparison with Fig. 19 shows that the curves are characteristic of adsorption.

Comparison of the curves with each other at the same dilution shows the relative amounts of the different acids adsorbed.

From the results presented above, it is apparent that the reaction by which undissolved casein reduces the concentration of an acid solution is one of adsorption and not the formation of either a stable or a hydrolyzible salt, as is shown by the absence of either constant combining proportions or a constant concentration of acid at equilibrium.

Casein is not the first proteid whose adsorptive power for acids has been studied. Walker and Appleyard[1] found that silk fixed varying proportions of mineral, fatty and aromatic acids, the aromatic being adsorbed most completely, mineral acids next, and fatty acids least; and it was shown that the reaction was one of adsorption. Schmidt[2] found that the process by which silk fixed the acid dye, eosin, is one of adsorption and concluded from this and other data that the dyeing of silk is an adsorption phenomenon. Sjöqvist[3] found that coagulated egg albumin takes hydrochloric acid and sulphuric acid from solution, and that the acids could be re-extracted from the albumin with water, the reaction being characteristic of adsorption, although Sjöqvist attributes it *a priori* to the formation of a hydrolyzible albumin-acid salt. Using in each case 2 grains of albumin for 100 cc. of acid, he found that in five minutes, 72, 83 and 91 per ct. of the acid was removed from solutions, respectively, of N-10, N-20 and N-40 concentration. It is apparent that, although the time of reaction was too short to permit final conclusions, the results suggest an adsorption, inasmuch as the concentration of the acid was reduced in all cases and more markedly as dilution increased, and showed no tendency towards an equilibrium constant. Hardy[4] calls attention to the fact that the reacting masses of dissolved globulin and acid are not constant, and he is inclined to suggest the possibility that the relation between electrolytes and proteids, even in solution, may be one of adsorption, the prteid molecules being gathered into minute masses in suspension, which form an "inner phase" more or less rich in adsorbed electrolyte. Hardy emphasizes the "need for caution in regarding the reaction between proteids and acids as one of simple salt formation.

[1] *Jour. Chem. Soc.* [*London*], *Trans.*, 69:1334. 1896.
[2] *Ztschr. Phys. Chem.*, 15:60. 1894.
[3] *Skand. Arch. Physiol.*, 5:35. 1895.
[4] *Jour. Physiol.*, 33:300. 1905

The possibility of the phenomena belonging to the intricate borderland of adsorption combinations must not be lost sight of."

The selective action of casein in taking acids but not neutral mineral salts from solution is paralleled by that of charcoal. Freundlich (loc. cit.) finds that a carefully purified preparation of the latter adsorbs mineral and organic acids, particularly the latter, but alters the concentration of mineral salts by less than one per ct. In this case the adsorbent is equally inert in a chemical sense towards either acids or salts. The reaction is purely one of surface energy, independent of any possibility of chemical combination between adsorbent and dissolved substance, and the same may be the case with casein.

It appears, however, that in all cases adsorptive power and the tendency to react chemically are not so sharply separated. van Bemmelen[1] says: " If P and C (adsorbent and dissolvent substance) are indifferent to each other according to the ordinary chemical conception, an adsorption may occur, but it is in many cases only a weak one." He found that the hydrogel of SiO_2 adsorbed strong bases much more strongly than strong acids or salts. MnO_2, which has acid properties and can combine chemically with strong bases, adsorbs alkali better than it does acids or salts. Metastannic acid, which can form combinations with acids, adsorbs potassium chloride weakly, hydrochloric acid strongly. From these and other similar facts, van Bemmelen concludes that it appears that " in many cases adsorption is distinguished as the *forerunner of chemical combination."* Adsorption is strong in many cases when, under other conditions or by gradual inner changes, chemical compounds can be formed. For example, van Bemmelen found[2] that colloidal silica in contact with barium hydroxide adsorbed the latter in accordance with the criteria of adsorption, so long as barium hydroxide of less than a certain concentration was used. When this concentration was exceeded, combination occurred and a compound having the composition $BaSiO_3 . 6H_2O$ separated in crystalline form. In double transposition in solution, as between salt and salt, the new compound is often precipitated as a colloid and changes later into a

[1] *Ztschr. Anorgan. Chem.*, 23:342.
[2] *Ztschr. Anorgan. Chem.*, 36:380. 1903.

chemical compound of crystalline form and definite composition. It is questionable whether the colloidal precipitate first formed is a chemical compound of definite proportions rather than an adsorption compound, or a transition between the latter and a definite chemical compound. van Bemmelen has determined the transition of precipitated colodial adsorption compounds of Al^2O_3, BaO, and CuO into chemical compounds.

From the standpoint of van Bemmelen discussed in the preceding paragraph, viz., that a chemical affinity between two substances, insufficient to cause a chemical reaction under existing conditions, may result in the formation of an adsorption compound, which may or may not give rise to a definite chemical compound, one may regard the action between casein and acids, by which insoluble acid-casein with varying content of acid is formed, as the formation of an adsorption compound under such influence; and the change to soluble acid-casein formed on long standing, on warming or on contact with acids above a certain degree of concentration, as the change of the adsorption compound into a chemical one, such as a proteid-acid salt.

Assumptions aside, however, as to the possible relation between the basicity of casein and its adsorptive power, and as to the nature of soluble acid-casein, the action of dilute acids may be briefly stated thus: The acids first concentrate upon the casein by adsorption and then begin to dissolve it more or less slowly according to conditions of temperature concentration, etc. The dissolved substance, at least in the case of hydrochloric acid, contains more acid than the adsorption compound.

The fact that acid-casein does not dissolve in warm 5 per ct. salt solution, as found by Van Slyke and Hart[1] is explained by the work of Hardy (loc. cit.) who found that the presence of acids decreases or inhibits the solvent power of salt solutions towards proteids. When the insoluble acid-casein is treated with salt solution, the latter would naturally extract part of the adsorbed acid, and largely lose its solvent power.

Although the results obtained during our limited time of investigation in this line of work are not complete, the facts that have been

[1] N. Y. Agr. Ex. Sta., Bul. 261. 1905.

presented, viewed in the light of our present knowledge regarding reactions having similar characteristics, have forced us to regard the action studied as a case of adsorption, with the formation of what van Bemmelen calls "adsorption compounds," that is, physical combinations with composition varying continuously with the conditions. It must be confessed that much remains to be learned about adsorption compounds, and the phenomena of adsorption. They, however, have certain characteristics in common, as summarized on p. 262, and the possession of these characteristics by the reaction between dilute acids and casein, together with the complete failure of the reaction to agree with the accepted laws of chemical combination, lead us to classify the process as an adsorption. Whether other proteids also take up acids by adsorption, or whether casein and silk are peculiar in this respect, it is useless to speculate about until careful quantitative tests have been made with other proteids.

For an interesting speculation upon the possible biological significance of adsorption, the reader is referred to the discussion at the close of Freundlich's recent paper.[1]

Viewing the action between casein and acids as an adsorption practically brings us back to Hammarsten's original proposition, in regarding the action as one not strictly chemical; though his conclusion was based on results that could not be accepted as at all decisive, especially in view of the facts we now possess which were not then known.

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[1] *Ztschr. Physik. Chem.*, 57:385. 1906.

THE HYDROLYSIS OF THE SODIUM SALTS OF CASEIN.*

1. In determining the amount of alkali neutralized by casein, different indicators give different results. Phenolphthaleïn has been in most common use in such work, giving higher results than other indicators. The object of the work presented was to determine the neutral point by means of conductivity measurements in comparison with the use of phenolphthaleïn and alkali. Our results indicate that the sodium salts of casein hydrolyze so readily that titration with alkali does not give the true equivalent weight of the proteid. An excess of casein, as of phosphoric acid, is required to overcome the alkalinity of the hydrolizing normal salt. The point at which the alkalinity is overcome is indicated by the attainment of minimum conductivity and corresponds roughly with the point neutral to phenolphthaleïn. Because of the extreme weakness of its acid properties, markedly greater excess of casein is required to give an acid reaction with less delicate indicators.

In determining the amount of alkali that is neutralized by casein, the results obtained by the use of different indicators do not agree. Thus, more alkali is required with litmus than with methyl orange and still more with phenolphthaleïn.[1] The amount of alkali which casein neutralizes, with the use of phenolphthaleïn as indicator, has been chosen somewhat arbitrarily as representing the true result. It was on the basis of results thus obtained that Laqueur and Sackur[2] made their determination of the equivalent weight of casein.

The desirability of a method of measuring the neutral point in such cases, independently of indicators, is apparent. It was hoped that the determination of electrical conductivity would furnish this. It is well known that when an acid is added to a solution of a strong base, the conductivity of the solution decreases until the neutral

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*Reprint of Part II, Technical Bulletin No. 3.

[1] Söldner *Landw. Vers.-Stat.*, 35:351. 1888.
Courant. *Arch. Physiol.* [*Pflüger*], 50:109. 1891.
Laqueur. *Beitr. Chem. Physiol. u. Path.*, 7:273. 1905.

[2] *Beitr. Chem. Physiol. u. Path.*, 3:197. 1903.

point is reached, because the addition of acid replaces rapidly conducting OH′ ions with more slowly conducting acid radicle anions. The addition of a given amount of acid always replaces the same number of OH′ ions, and decreases the conductivity by a given amount; therefore, if the conductivities are plotted as ordinates and the amounts of acid added, volume of solution being constant, as abscissae, the resulting curve will be a straight line sloping downward to the neutral point. At this point it breaks sharply. If the acid be a strong one, like sulphuric acid (Fig. 21) the curve will rise again rapidly in a nearly straight line. If the acid be a weak polybasic one, like succinic, the curve may still continue falling slightly on the acid side of the neutral point, due to the fact that the acid-salt has somewhat lower conductivity than the neutral, but the slope is slight compared with that on the alkaline side of the neutral point, and the point is plainly marked by a sharp angle. If the acid be so weak, however, that it hydrolyzes, so that its normal salt reacts alkaline, as is the case with phosphoric acid, the curve does not fall straight to the neutral point and break there, but bends gradually (H_3PO_4, Fig. 22), and without breaking. The decrease in the number of OH′ ions is not a linear, but a complex function of the amount of acid added, and they do not disappear until an excess of acid has been added. In acids of this character, the neutral point can not be determined accurately by either conductivity or titration with phenolphthaleïn. Sjöqvist[1] working with hydrolyzible hydrochloric acid salts of albumin employed the approximate method of determining the intersection of the asymptote of the curve on the acid side (corresponding to the alkaline in our case), with the horizontal line tangent to the curve at its minimum, assuming that the abscissa of the intersection denoted the equivalent weight of albumin.

The work of former investigators has shown that the addition of more casein to a sodium caseinate solution neutral to phenolphthaleïn does not appreciably change the conductivity. Instead of the curve's rising beyond the neutral point, as in the case of sulphuric acid, or falling slightly, as in the case of succinic acid, it becomes horizontal. If an acid sodium salt of casein, analogous to

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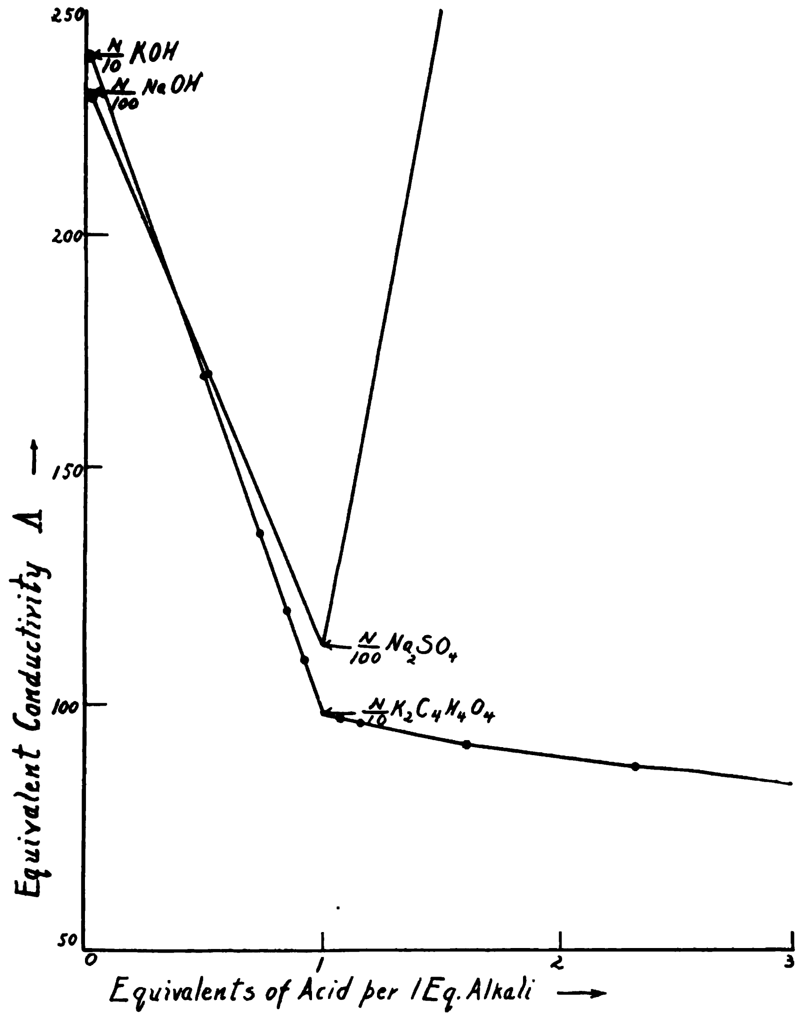
[1] *Skand. Arch. Physiol.*, 5:276. 1895.



250
200
150
100
50
$\frac{N}{10}$ KOH
$\frac{N}{100}$ NaOH
$\frac{N}{100}$ Na_2SO_4
$\frac{N}{10}$ $K_2C_4H_4O_4$
Equivalent Conductivity Λ
0
1
2
3
Equivalents of Acid per 1 Eq. Alkali

FIG. 21.

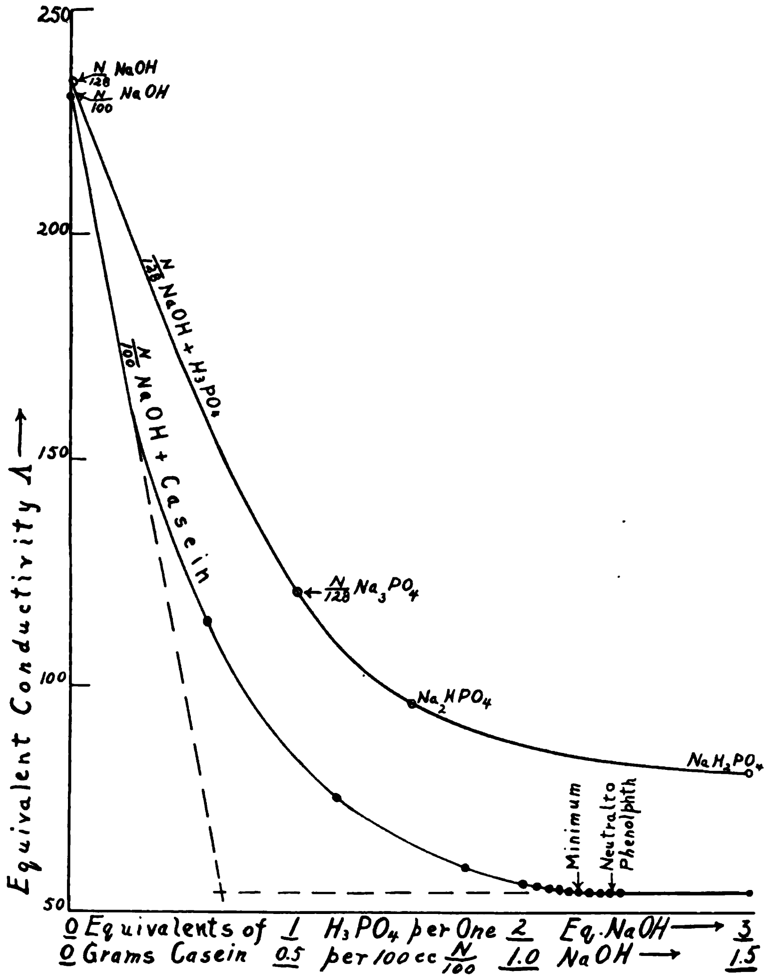

250
200
150
100
50
N/128 NaOH
N/100 NaOH
N/128 NaOH + H3PO4
N/100 NaOH + Casein
N/128 Na3PO4
Na2HPO4
NaH2PO4
Minimum
Neutral to Phenolphth
Equivalent Conductivity Λ →
0 Equivalents of 1 H3PO4 per One 2 Eq. NaOH → 3
0 Grams Casein 0.5 per 100 cc N/100 1.0 NaOH → 1.5

FIG. 22.

$NaHCO_3$, is formed, this acid salt has apparently the same conductive as the neutral salt. Apparently the (H casein),$^{n-1}$ (H_2 casein)$^{n-2}$ . . . . . ions have the same conductivity as the (casein)^n ion (n = valence of casein anion), the gain or loss of a hydrogen atom not appreciably affecting the velocity of the excessively large and complex casein anion.

Laqueur (*Beitr. Chem. Physiol. u. Pathol.*, 7:273. 1905) mentions the fact that increase in the proportion of casein in a solution of sodium caseinate neutral to phenolphthaleïn does not appear to change the conductivity, and discusses the explanation mentioned above, also as less probable the one that the excess casein simply dissolves as free casein in the sodium caseinate solution.

The constancy of the conductivity of solutions acid to phenolphthaleïn is shown more accurately by the figures of Long (*Jour. Amer. Chem. Soc.*, **28**:377. 1906), although he does not call attention to this feature. Rearranging Long's results, so as to make this point clear, we have the following table:

c. c. $\frac{N}{10}$ Na OH. in 100 c. c.	Grams casein.	Conductivity $\times 10^6$	Reaction to phenolphthaleïn
22.50	1.25	1234	alkaline
	2.5	1006	neutral
	5.0	1012	acid
11.25	0.625	700	alkaline
	1.25	561	neutral
	2.50	563	acid
5.625	0.3125	380	alkaline
	0.625	310	neutral
	1.25	308	acid
2.812	0.1562	209	alkaline
	0.3125	172	neutral
	0.6250	168	acid
1.406	0.1562	93	neutral
	0.3125	93	acid

The last two figures of each trio in the conductivity column agree closely.

From the above discussion it is apparent that if casein acts as an acid with a definite neutral point correctly indicated by phenolphthaleïn, as was apparently considered to be approximately the case by Laqueur and Sackur,[1] who based equivalent and molecular weight determinations upon this assumption, we should expect a neutralization conductivity curve descending in a straight line to the neutral point, and there breaking and becoming horizontal.

[1] *Beitr. Chem. Physiol. u. Pathol.*, 3:193. 1903.

The curve actually obtained (Fig. 22) is concave and gradually approaches the horizontal position without the occurrence of a break at any point. The curve reaches its minimum at a point near that neutral to phenolphthaleïn, but it does not appear that this point indicates the normal salt any more than the minimum on the phosphoric acid curve indicates Na_3PO_4. It indicates rather the presence of sufficient excess of casein to depress the amount of hydrolytically freed NaOH to a negligible quantity. If we adopt Sjöqvist's method, and extend the asymptote of the upper part of the curve, until it cuts the horizontal line tangent at the minimum (dashed lines Fig. 22), the intersection indicates an equivalent weight of casein less than one-third that estimated from the point neutral to phenolphthaleïn. The assumption of Laqueur and Sackur's, that the latter indicates approximately the true equivalent weight of casein is not confirmed. It does not appear that this can be ascertained by titration with acid-alkali indicators any more than can that of phosphoric acid, altho as applied by Robertson[1] it may furnish the basis of a convenient empirical method for quantitative estimation of the proteid.

EXPERIMENTAL.

We dissolved varying amounts of casein in 100 cc. of $\frac{N}{100}$ NaOH and determined the point of minimum conductivity by the method of repeated approximation, finding the point within wide limits, then working within these and finding narrower limits, etc. The methods of manipulation in agitating casein with alkali and in measuring conductivities were the same as in the case of acids. The solutions were thus in contact with the electrodes only a short time, avoiding chances of the difficulty mentioned by Laqueur.[2]

We obtained the following results graphically expressed in Fig. 22, using in each case 100 cc. of $\frac{N}{100}$ NaOH with the amounts of casein indicated.

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[1] *Am. Jour. Biol. Chem.*, 2:317.
[2] *Beitr. Chem. Physiol. u. Pathol.* 7:275. 1906.

Grams of casein.	Equivalent conductivity Λ	% free NaOH from conductivity.	Color of solution with phenolphthalein.
0	232.0	100.00	Red.
0.291	114.0	33.55	Red.
(0.335)	(106.0)	(29.05)	Red.
0.581	75.7	12.00	Red.
0.872	59.7	2.98	Red.
1.000	56.2	1.01	Red.
1.030	55.4	0.56	Red.
1.060	55.1	0.39	Red.
1.080	54.9	0.28	Red.
1.100	54.7	0.17	Red.
1.120	54.4	0.00	Red.
1.140	54.3	"	Red.
1.160	54.4	"	Red.
1.180	54.3	"	Red.
1.200	54.3	"	Slightly pink.
1.500	54.4	"	Colorless.
1.800	54.4	"	Colorless.

The numbers in parentheses are graphically interpolated from the curve, and correspond to the point indicating the normal salt, according to Sjöqvist's roughly approximate method. This normal salt, with no excess of casein present, appears about 29 per ct. hydrolyzed. The free alkali in the data tabulated below this in the column may be regarded as all due to hydrolysis.

The per ct. of free NaOH in the third column is calculated by the formula usually employed for hydrolysis $k_1 x + (1-x) k_2 = k_3$; $100 x =$ per ct. of free alkali; $k_1 =$ conductivity of free alkali $= 232$; $k_2 =$ conductivity of unhydrolyzed sodium caseinate $= 54.4$; $k_3 =$ observed conductivity of experimental solution. The accuracy of the formula depends on that of the observation brought out previously that the equivalent conductivities of the neutral and various acid sodium salts of casein are the same.

The view that the sodium salts of casein hydrolyze was held by Laqueur and Sackur[1] for the salts acid to phenolphthaleïn. Our

[1] *Beit. Chem. Physiol. Pathol.*, 3:194. 1903.

results indicate that the salts even quite alkaline to phenolphthaleïn hydrolyze to a marked degree.

The behavior of casein salts of the alkaline earth metals has also been studied by W. A. Osborne[1] with the conclusion that they hydrolyze.

A further reason for placing casein, as regards its acid properties, in a class with phosphoric acid, is the similar behavior of the two towards various indicators. Phosphoric acid like casein gives different results when titrated against alkali with different indicators. For example, 10 cc. of a given solution of phosphoric acid was neutralized to methyl orange by 6.15 cc. N-10 KOH, while to give a perceptible pink with phenolphthaleïn 11.20 cc. were required.

Viewed from the standpoint indicated by our results, casein acts as a very weak acid. When a sufficient excess of casein is present in solution (presumably as acid casein salts, possibly as free casein dissolved in sodium caseinate solution) the amount of hydrolytically freed alkali is reduced to practically zero, and the solution reacts neutral to the delicate indicator phenolphthaleïn, at the same time showing a minimum conductivity. Due to the weakness of its acid properties, a considerably greater excess of casein is required to render the solution acid enough to redden litmus, and still greater excess to neutralize to methyl orange.

These results are presented as preliminary to a more thorough investigation of the problem.

The data for plotting the H_3PO_4 and H_2SO_4 curves are taken from Kohlrausch.[2] The data for succinic acid were obtained by adding to a solution of 20 cc. carbonate-free $\frac{N}{10}$ KOH in a conductivity cell successive portions of recrystallized succinic acid dried at 115°. The acid was weighed out in a small tube and portions shaken into the solution, the tube being weighed after shaking out each portion. By this method cumulative error in weighing was avoided. As one equivalent of succinic acid weighed but 116 milligrams, the volume change caused by the addition was negligible. The following data were obtained. Temperature = 25°.

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[1] *Jour. Physiol.*, 27:398. 1901.

[2] Leitvermögen der Elektrolyte.

Equivalents succinic acid added.	Λ
0	240.0
.500	171.7
.723	138.0
.840	121.4
.913	111.6
.983	102.0
1.043	99.1
1.149	97.8
1.614	93.1
2.331	88.7
3.100	86.2

For courtesy in providing us with apparatus, laboratory and materials for the above experiment, which was done when our own apparatus was not available, we wish to thank Dr. Lind, of the University of Michigan.

REPORT

OF THE

Department of Entomology.

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F. A. SIRRINE, *Special Agent.*

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REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

COMMERCIAL MISCIBLE OILS FOR THE TREATMENT OF THE SAN JOSE SCALE.*

P. J. PARROTT, H. E. HODGKISS AND F. A. SIRRINE.

SUMMARY.

This bulletin contains the details of a number of experiments with commercial miscible oils to determine their merits for the control of the scale. This work was conducted in three orchards in which 1368 trees were sprayed with these preparations in varying proportions. On the basis of these tests the following conclusions are drawn:

Applications of proprietary miscible oils at the rate of one part of oil to twenty or twenty-five parts of water failed to give uniform results on scale. Trees receiving these treatments usually showed more or less spotting of the fruit and varying infestation of the new growth.

Miscible oils in the proportion of one part of oil to ten or fifteen parts of water, while uniformly more destructive to the scale than the weaker preparations, were usually not quite so efficient as the boiled lime-sulphur wash. These stronger applications destroyed large percentage of the scales, being sufficiently effective to maintain the thriftiness of the trees and to keep the fruit crop fairly clean. On the basis of these results even the better ones of the miscible oils tested should not be used in weaker mixtures than one part to ten or fifteen parts of water.

*A reprint of Bulletin No. 281.

The miscible oils are commercial insecticides and therefore the orchardist should understand that the reliability of the stock material rests with the compounder. These sprays are simple to prepare for use, and are convenient preparations for the treatment of odd trees and small orchards. The cost of the miscible oils in the proportions of one part to ten or fifteen parts of water makes their use almost prohibitive for commercial orchardists who desire a safe and comparatively cheap oil spray. Compounders of commercial insecticides should endeavor to produce a reliable miscible oil that is cheaper than present brands.

COMMERCIAL MISCIBLE OILS FOR TREATMENT OF THE SAN JOSE SCALE.

Crude and refined oils are among the most penetrating and destructive of the contact insecticides, but as ordinarily employed for spraying purposes they must be used with much caution to prevent the applications from injuring the plant while destroying the insect. Rather than run the risks of injuries to his trees the average fruit-grower has largely avoided clear oils for orchard treatment. For these reasons a safer method for the use of oils in this capacity has long been desired. To meet this demand there have appeared upon the market in recent years a number of sprays which have been designated Miscible Oils or Water-Soluble Oils. These preparations have proprietary names and are known as Kil-o-Scale, Scalecide, Target Brand Scale Destroyer, Surekill, Water-Soluble Petroleum, etc. The important ingredients in the more efficient of these commercial insecticides are oils which have been combined with some emulsifying agent to facilitate a uniform dilution with water. In these emulsion preparations, oils are usually rendered safer for the treatment of trees while retaining much of their destructive properties upon insect life.

The commerial miscible oils are concentrated liquids and cost from 50 cents to $1.25 per gallon, depending on the quantity purchased. The preparation of the mixture for use is simple. The directions on the container usually advise the operator to dilute with water using one gallon of the miscible oil to twenty or twenty-five gallons

of water, and then to stir until an even distribution of the ingredients is secured. The prepared spray usually contains no sediment and there is ordinarily no clogging of the nozzles.

EXPERIMENTS WITH MISCIBLE OILS.

Following the general plan adopted by the Station in conducting tests of spraying mixtures for the control of the scale, separate blocks of apple, peach, pear and plum trees were selected for treatment. All the trees were thrifty, and, while they were not usually incrusted, the scales were plainly visible upon the bark. In each of the plats applications of miscible oils were made according to the printed directions, using various strengths; and, for the purpose of determining the comparative merits of the respective spraying mixtures, the rows immediately adjacent to trees receiving the oil treatment were sprayed with the kerosene-limoid mixture and the sulphur washes. The miscible oils used in these tests were Scalecide, Kil-o-Scale and Surekill. All the trees were sprayed once and as soon as they were dry were treated again for the purpose of thoroughly covering the parts imperfectly coated by the first application. These tests were made in seven orchards. This bulletin contains the details of the work in three of the orchards which are fairly representative and which are sufficient to indicate the trend of the results of the experiments. The number of trees in these three orchards sprayed with miscible oils is 1368, divided as follows: Orchard I, 43 trees; Orchard II, 46 trees; and Orchard III, 1279 trees.

DETAILS AND RESULTS OF EXPERIMENTS.

ORCHARD I.

In this orchard 33 plums of ten years of age and 10 apples of twenty-three years of age were sprayed with Scalecide or Kil-o-Scale at the rate of one part of miscible oil to either fifteen or twenty parts of water. The applications were made December 13, 1905. All trees, especially the apples, were well infested with the scale. Blossoming commenced May 4 and continued till May 16. A number of trees did not blossom. This, it is thought, was not attributable to the treatment. With this exception the appearance of the trees was normal.

Results on scale: Plums.— On June 17, 1906, active young scale insects were detected on all trees with the exception of the plums sprayed with the sulphur washes. The breeding of the scale continued throughout the summer; and by fall the worst infested trees that had received treatment with Scalecide and Kil-o-Scale had more scales than in the previous year. On the moderately infested trees the results with the miscible oil compared favorably with those obtained by the sulphur washes.

Apples.— On May 4 an examination of a number of branches showed that about one-half of the scales were alive on trees sprayed with Scalecide and Kil-o-Scale, the applications of these oils proving much less effective on apples than on plums. There was also some spotting of the fruit by the scale on the trees sprayed with the sulphur washes but the blemishes were much less abundant and less conspicuous than on the apples from the trees sprayed with the miscible oils. Two of the trees sprayed with Scalecide were so badly injured by the scale that the owner cut them down in the fall of 1906.

ORCHARD II.

In this orchard 14 apple trees of twelve years of age, 24 plum trees of eight years of age, 6 peach trees of five years of age, and 2 cherry trees of five years of age, were sprayed with either Kil-o-Scale, Scalecide or Surekill, using one part of the miscible oil to either fifteen, twenty or twenty-five parts of water. The applications were made on April 23, 1906. Every tree in this block was well infested and occasionally one was much incrusted.

Results on scale.— On May 3 blossoming commenced which was normal for all trees with the exception of two plums and six peaches which showed much retardation of the fruit and leaf buds by the miscible oils. Three of the injured peaches died during the early summer. On June 22, a few young scales were found on plums sprayed with one part of Scalecide to twenty parts of water. Two peaches that were much incrusted with the scale in 1905 showed, as a result of the treatment with Scalecide at the rate of one part to fifteen parts of water, hardly any evidences of larval activity. During the summer these two trees produced much new growth which was free of scale throughout the season. All the apples,

peaches and cherries sprayed with Scalecide at the rate of one part to twenty parts of water were so badly infested that resort had to be made to summer spraying to save the trees. Kil-o-Scale at the strength of one part to fifteen parts of water practically destroyed the scale, as there was very little evidence, even late in the fall, of larval activity. Preparations of Kil-o-Scale in the proportions of one part to twenty of water killed a large percentage of the scales. This enabled the trees to make a good growth, and they showed only a slight amount of infestation. Surekill was less effective in this experiment than either Scalecide or Kil-o-Scale, and applications of Surekill at rates of one part to either twenty or twenty-five parts of water had no appreciable effects upon the scale, as the trees sprayed with this preparation were, at the end of the summer, as badly infested as the checks.

ORCHARD III.

In this experiment 447 apple trees of five to eight years of age, 384 pear trees of seven years of age, and 448 peach trees of five years of age, making a total of 1,279 trees, were sprayed with Scalecide during April, 1906. This spray was used at two strengths. One lot of 416 trees, including the three kinds of fruit, was sprayed with one part of the miscible oil diluted with ten parts of water and another lot of 863 trees was treated at the recommended strength of one part of the oil to twenty parts of water. The orchards were especially adapted for the purpose, as the trees have been given good care, and were thrifty and small in size. In the past, the owner has used clear oils, mechanical oil-emulsions, kerosene-lime wash and a small quantity of the sulphur wash to control the scale. This pest has been present in the orchards for about six years. The infestation varied with the individual trees but there was hardly a tree that did not have a good sprinkling of the scale, and many trees in each row showed more or less incrustation. In this experiment the rows immediately adjacent to a row treated with Scalecide were sprayed with kerosene-lime wash (15 per ct. or 30 per ct. oil) and the boiled lime-sulphur wash. In each block of the different kinds of fruit, one row was left unsprayed as a check.

Results on scale.— Many scales were not affected by the treatment with Scalecide, using one part diluted with twenty parts of water.

Early in June active larvæ were abundant on trees receiving this treatment. An examination of the orchards on Aug. 15 showed that the trees, especially the apples, were but very little better, on the average, with respect to the scale than the checks. Many pears, and some apples, were too much spotted with scale to grade as firsts. Similar conditions with respect to scale existed on a large part of the trees sprayed with kerosene-lime wash containing 15 per ct. of oil. The applications of Scalecide containing one part to ten parts of water showed some variation in their effects upon scale. Some of the treatments were quite as effective as the sulphur washes, while others were noticeably less efficient. There was hardly a tree that did not show more or less living scale at the base of the new growth. Likewise there was more or less spotting of the fruit, especially of the pears, but on the whole, the scale was sufficiently controlled by the 10 per ct. miscible oil to maintain the thriftiness of the trees and to insure the production of fairly clean fruit. The trees sprayed with the sulphur washes, while showing more or less evidence of living scales, had their new growth more uniformly free of scale and the fruit comparatively clean. The results on fruits were especially marked in the case of the pears, for the sulphur-treated trees produced a remarkably clean crop while the yield from the trees sprayed with 10 per ct. miscible oil showed more or less spotting by the scale.

SUMMARY OF RESULTS.

Fall applications of Scalecide and Kil-o-Scale in the proportions of one part to either fifteen or twenty parts of water caused no appreciable injuries to fruit or leaf buds. The effectiveness of these preparations upon the scales was variable. On the moderately infested plum trees the numbers of the scales destroyed by the sprays in these proportions compared favorably with the results obtained by the sulphur washes, while badly infested plum and apple trees received very little benefit by similar applications of the commercial preparations. In the tests conducted in the spring, applications of one part of Scalecide to twenty parts of water usually failed to control the scales, but when this spray was used in stronger mixtures, of one part to either ten or fifteen parts of water, the new growth and fruit of the trees were kept quite clean. One applica-

tion of a sulphur wash was usually more effective than one application of a miscible oil in either of these proportions. In one test Kil-o-Scale at the rate of one part to twenty parts of water proved more effective than a mixture of Scalecide in the same proportions, but on the whole there was very little difference in the relative effectiveness of these sprays when the amount of dilution was the same. Surekill applied as recommended had no appreciable effects upon the scales.

CONCLUSIONS.

Applications of proprietary miscible oils at the rate of one part of oil to twenty or twenty-five parts of water, as recommended in the printed directions, did not give uniform results on the scale. Trees sprayed with these strengths in the fall or in the spring usually showed more or less spotting of the fruit and varying infestation of the new growth. Ordinarily not enough scale was destroyed by the miscible oils, in these proportions, to warrant a fruit-grower taking chances on the trees, unless supplementary summer or fall treatments are to be made. The treatments were usually much more effective on trees that were slightly infested than on those showing incrustation of the scale. Surekill was the least efficient of the miscible oils that were tested.

Applications of a miscible oil in the spring at the rate of one part of oil to ten or fifteen parts water, while uniformly more destructive to the scale than the weaker preparations, were usually not quite so effective as the sulphur washes. Preparations of miscible oils in these proportions killed enough of the scale to maintain the vigor of the trees and to secure fairly clean fruit yields.

DIRECTIONS FOR USING MISCIBLE OILS.

On the basis of these experiments it is evident that the miscible oils tested must be used stronger than is recommended by their compounders to obtain satisfactory results on the scale. Therefore instead of using one part of oil to twenty or twenty-five parts of water the orchardist is advised to use at least one part of the miscible oil to ten or fifteen parts of water. Before measuring out the required quantity from its container, vigorously stir or shake

the miscible oil to secure a thorough distribution of its ingredients. The failure to follow the directions in this respect is undoubtedly responsible for some of the poor results with these preparations. Before making applications, the oil and water should be well mixed by the spraying agitator. Spray in the spring as the buds are swelling, during a period of clear weather when the trees are dry. The applications must be thorough so that all parts of the trees are completely wet with the spray. If the base of the new growth should during the summer show quite a little infestation, then spray again in the fall as soon as the majority of the leaves have fallen. Spraying in the fall, especially of peaches and plums, is usually not advisable because of the risk of injury to fruit buds. But rather than run the chances of the continuation of injuries by the late breeding of the scale or the neglect of the treatment in the spring, fall spraying is advised, as the increased vigor and usefulness of the trees arising from the control of the scale will more than compensate for probable losses in fruit yields.

The miscible oils are commercial insecticides and therefore the orchardist should understand that the reliability of the preparations rests solely with the compounder. These sprays are simple to prepare and they are discharged from the nozzle as an even mist, as there is usually no sediment or clogging of the nozzle apertures. At a price of fifty cents a gallon for the stock material, miscible oil in the proportions of one part to ten parts of water will cost about $2.50 per barrel of fifty gallons which is about five times the cost of the raw materials for making one barrel of a sulphur wash. Because of the ease in which they may be prepared for use, they are convenient sprays for the treatment of a few trees and of small orchards. The cost of the miscible oils in the proportions of one part to ten or fifteen parts of water makes their use almost prohibitive for commercial orchardists who desire a safe and comparatively cheap oil spray. Compounders of commercial insecticides should endeavor to produce a reliable miscible oil that is cheaper than present brands, as there is demand for an efficient and economical spray that may be prepared for use with greater ease than some of the present remedies.

THE APPLE AND PEAR MITES.*

P. J. PARROTT, H. E. HODGKISS AND W. J. SCHOENE.

SUMMARY.

This bulletin is a preliminary treatise upon the Eriophyidae, a group of plant-inhabiting mites of increasing economic importance, in which special attention is given to the species thriving upon the apple and the pear. This investigation was undertaken because of the appearance of the leaf blister-mite upon apple foliage, and its widespread distribution in destructive numbers in the apple orchards of Ontario, Orleans, Wayne and Niagara counties.

In the study of the mites upon apple and pear leaves, five species have been recognized, which are *Eriophyes malifoliae* Parr., *Eriophyes pyri* (Pgst.) Nal., *Eriophyes pyri* var. *variolata* Nal., *Phyllocoptes schlechtendali* Nal., and *Epitrimerus pyri* Nal. With the exception of the former, which is new, these species were first recorded from Europe. *Eriophyes pyri* (Pgst.) Nal., known as the leaf blister-mite, is the most abundant species and is responsible for the conspicuous injuries to apple foliage.

The leaf blister-mite is a small, vermiform, four-legged animal, about one one-hundred and twenty-fifth of an inch in length and hardly visible to the unaided eye. It hibernates in the buds and with the maturing of the bud scales seeks the tender leaves, which it punctures, producing light green and reddish pimples. These develop into galls or blisters of a blackish or reddish brown color, depending on the kind and the variety of fruit. Besides the pear and the apple, the mite attacks the service berry, the common cotoneaster, the white beam tree, and the mountain ash. It is an important pest of the pear in nurseries and of apple and pear orchards.

*A reprint of Bulletin No. 283

Nursery stock is commonly infested; and, when the mite is abundant, pear foliage is much discolored, and the young trees may be stunted through the destruction of the terminal leaves of the new growth. The appearance of the mite for successive years in the nursery is due to methods of budding. The experiments to control the mite in nurseries are not completed, but it is believed that the pest can be eliminated from the nursery by the selection of buds from clean stock, and by the fumigation of budding sticks.

In the experiments upon apple trees comparative tests have been made with kerosene oil, miscible oil, kerosene emulsion, whale oil soap and the sulphur washes; and of these sprays, kerosene either clear or emulsified, and the miscible oil, proved the most efficient remedies for the mite. Because of its safe qualities and cheapness, kerosene emulsion, diluted with five parts of water, applied during the dormant season, appears to be the most practical remedy for the spraying of apple orchards, when treatment is advisable. The mite may be efficiently controlled upon pear trees by careful pruning and by spraying during the late fall or early spring with kerosene emulsion, miscible oils or the sulphur washes. The mite is much more readily controlled upon pear trees than upon apple trees.

INTRODUCTION.

The apple has many insect enemies, and hardly a year passes but that a species develops in sufficient numbers to alarm the fruitgrowers of this State. The rapid rise of a common insect, from comparative obscurity to a position of first prominence within one season, followed in turn by its almost complete disappearance in as short an interval of time, is one of the most interesting phases of animal life. Insects are especially capricious and their behavior in this respect is not entirely unexpected; but that a mite which had no reputation in this capacity and whose presence was entirely unsuspected, and not an insect, should so completely overrun our apple orchards brings surprise to many fruitgrowers. This mite has been on the increase during the past four years, and by its abundance and its conspicuous work on apple foliage, has caused quite a little apprehension among apple growers. Added interest has been given to the progress of this creature because of the growing importance of spray injuries, with which the work of the mite has been confused. In conducting the investigation to determine the cause and means of prevention of the peculiar diseased conditions of apple leaves it was found necessary to include the pear, as several species of mites are common to both fruits.

In the study of the mites subsisting upon apple and pear leaves, four species, all of foreign origin, have been distinguished, the more important being *Eriophyes pyri* (Pgst.) Nal., long recognized as a destructive pest of the pear. This group of plant-inhabiting mites is little understood, and that there may be a greater appreciation of them, especially of the species under discussion, an introductory review is given of the Eriophyidae as a preliminary to a more extensive treatise.

Special acknowledgments are due to Dr. Alfred Nalepa, of Vienna, who has verified all the determinations and has furnished copies of his valuable monographs upon the Eriophyidae, which have been freely consulted. Prof. J. H. Comstock of Cornell University has kindly given much advice upon methods of making permanent mounts and has allowed the use of his library for reference purposes. Dr. Karl Rechinger, Vienna, and Mr. Edward T. Connold, St. Leonards-on-Sea, England, contributed a number of pho-

tographic prints and mounted specimens, illustrating the work of *Eriophyes pyri* upon its various host plants. For the determination of various species of Gamasidae we are indebted to Dr. L. O. Howard, of the U. S. Bureau of Entomology.

THE MITES.

The mites belong to the Acarina which constitutes an order of the class Arachnida. Related forms are the true spiders, daddy-legs and scorpions. Because of their unattractive appearance and habits, and obscure structural characters, they have not been of the popular interest that obtains with the insects. To the average person, they are practically unknown. Nevertheless, they are common and abundant. Banks states that about three hundred and fifty species are recorded from this country where a thousand or more probably exist. A large number of the mites play an important role in human economy. Among the more prominent species are the cattle tick, the leaf blister-mite, the red mite, and the chicken mites, all of which are first class pests. Some of the mites find their subsistence upon animals and others thrive upon plants. One of the important groups of plant-feeders is the Eriophyidae which contains the species mentioned.

THE ERIOPHYIDAE.

STRUCTURE.

The mites included in this family are small four-legged animals of a vermiform shape, that are hardly visible to the unaided eye. They vary in size according to the species. The female of *Eriophyes mentharius* Can., which is one of the largest known mites, is 310 microns (one-eightieth of an inch) long, while the female of the *Eriophyes parvulus* Nal., the smallest known species, is 100 microns (one two hundred and fiftieth of an inch) long. The body has two distinct parts: The anterior which is broad and short, and which consists of a head fused with a thorax, and is known as the cephalothorax; and the posterior or abdomen, which is much longer, and is annulated and tapering.

The head appears as a pointed snout which is bent and directed downwards. This contains two minute slender stylets, called man-

dibles, which serve for puncturing. On each side of the rostrum there is a three-jointed maxillary palpus used as an antenna. The second segment of the palpus has on its dorsal side one hair. Close to the rostrum there are two pairs of legs, one pair to a side, which are of similar size and shape. These project forward and are five segmented. A few small hairs are usually present on all but the basal segment, which are constant. Segment 2 has a short fine hair, segment 3 has a long stiff hair, and segment 5 has one long hair on the outer margin and a small one on the inner margin. The apical segment also has a small cylindrical claw which is sometimes swollen at the tip. Beneath the claw is a plumose hair, called a feathered hair, which ordinarily has four or five rays. In the region about the base of the rostrum and between the legs are three pairs of hairs, known as thoracic setae 1, 2, 3, respectively. The dorsum of the cephalothorax has one pair of hairs, the dorsal setae, and is often marked with sculptural designs which afford important taxonomic characters.

The abdomen is cylindrical and is transversely striated, giving the appearance of narrow rings. The number of striae may vary with the species. With some species the body is evenly ringed all round, and in others the number of rings on ventrum is larger than on dorsum. Between the rings are frequently small tubercles which are only apparent when highly magnified. At the extremity of the abdomen are two semicircular flaps, which may be at will brought closely together or withdrawn, and which serve for purposes of grasping and locomotion. Below the flaps is the anal opening. The genital openings are situated on the ventral surface of the abdomen close to the thorax. In the female the external portion, the epigynium, consists of two parts, a semicircular opening with a raised chitinous margin and a flaplike cover, while that of the male, the epiandrium, is smaller and appears as a simple opening, sometimes arched shape, with thickened margins. On the dorsum of the abdominal flaps there are two long whiplike bristles, the caudal setae, and usually two accessory hairs which are short and stiff. The abdomen has five other pairs of bristles. One pair is at the sides of the genital opening and is known as the genital setae. Near the margin of the body, beyond the genital opening, is one pair of lateral setae. The remaining pairs are also on ventral

surface and are known as ventral setae. Ventral setae (1) are always the longest, ventral setae (2) are usually very short, and ventral setae (3) are as a rule longer than (2) and are on the fifth or sixth ring from the end of the abdomen.

LIFE STAGES.

The eggs of mites are round, elliptical or oval, and have a thin delicate chitinous covering. They are whitish or yellowish in color, and are quite large compared with the size of the parent.. The young larvae are similar in appearance to the adults and are distinguished from them only by their smaller size, the less number of the setae, and the absence of the external parts of the genital organs. The nymph shows a further approach to the adult size and a greater development of the genital organs.

HABITS.

The Eriophyidae are plant feeders and for the most part confine their operations to the buds and leaves. Many mites cause excresences or galls and other deformities on the parts of the plant attacked, in which they find their habitation and subsistence, while others live as inquilines in the galls of other species or are vagrant, showing, with the exception of such forms as the citrus mite and peach leaf mite, little or no evidences of their feeding. The growths due to the work of mites were divided by Thomas[1] into Acrocecidii and Pleurocecidii. Under the former are included abnormal swelling of the buds and irregular bud growth. To the latter belong leaf galls, leaf blisters, folding and rolling of the leaves, unnatural coloring and chlorosis of the leaves. These hypertrophies of plants puzzled early investigators, who, little understanding the work of mites, classified the growths according to their form for convenience of reference. Among the more important genera established on this basis were *Taphrina*, *Erineum* and *Phyllerium* for abnormal hairy or fuzzy growths, *Volvolifex* for rolled edges of leaves, and *Cephaloneon* for distinct galls. These terms were commonly employed in the early literature upon mites.

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[1] Thomas F. *Ztschr. Naturw.*, 42:513. 1873.

HISTORY OF FAMILY.

The mites were first discussed in a vague manner by Reaumur[1] in 1737, who apparently observed some specimens of a mite, now known as *Eriophyes tiliae,* in galls upon the leaves of the lime tree. Later Turpin[2] examined the same species and named it *Sarcoptes gallarum tiliae.* In 1834 Duges[3] mentioned the observations of Turpin upon this species and expressed the opinion that the mites were larval forms of *Dermanyssus,* believing that all adult Acarina never possess less than four pair of legs. Siebold[4] in 1850 considered the mites as larvae, and suggested that they possibly propagated asexually and that the adult form was yet to be found. He provisionally employed the term Eriophyes to designate these creatures. During 1851 Dujardin[5] established the genus *Phytoptus* for two forms of mites upon linden and willow respectively, which he characterized as possessing only two pair of legs, an annulated abdomen and degenerated mouthparts. Dujardin detected ova in the abdomen and considered the mites adult forms. The true nature of the adult mite was conclusively shown by Landois[6] in 1864, after a careful study of the mite, *Eriophyes vitis,* an important pest of the grape. This group of mites has long been known as *Phytoptidae* which was formed on the genus *Phytoptus* of Dujardin, but lately writers have accepted *Eriophyes* (Siebold) which has one year's priority.

SYNOPSES OF GENERA.

The following synopses, which are based on Nalepa's descriptions, give the essential characters of the genera and serve for their identification. In point of numbers, *Eriophyes* is the most important genus, followed in order by *Phyllocoptes, Epitrimerus, Oxypleurites* and *Tegonotus,* which include all of the known species recorded in the United States.

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[1] Mémoires pour servir à l'hist. des Insectes. Paris, 1737, III: pp. 423-511.
[2] Floriep's Notizen, Weimar, 47:65. 1836.
[3] *Ann. Sci. Nat. Zool., Paris,* 1834, p. 104.
[4] Achtundzwangister Jahresber. d. schlesischen Ges. f. vaterl. Cultur, Breslau, 1850, Zweite Ber. über die Arb. d. entomolog. Section, S, 88-89.
[5] *Ann. Sci. Nat. Zool. Paris,* 1851, p. 166.
[6] *Ztschr. wiss. Zool.,* 14:353-364. 1864.

ERIOPHYES (Sieb.) Nal.— Dorsum and ventrum of abdomen with about the same number of striæ. Ventrum always punctured. Dorsum usually punctured, seldom partly or entirely smooth. Abdomen cylindrical, vermiform or slightly fusiform, seldom conspicuously wide behind shield.

MONOCHETUS Nal.— Similar to Eriophyes, with a longitudinal furrow on dorsum of abdomen.

PHYLLOCOPTES Nal.— Striæ numerous and narrow, seldom broad, gradually becoming narrower towards end of abdomen. Annulation of posterior portion of abdomen not distinct from remainder of abdomen. Dorsum smooth, not usually punctured. Ventrum with narrow striæ, always punctured.

ANTHOCOPTES Nal.— Anterior portion of dorsum of abdomen with few broad striæ, not punctured; posterior part with narrow striæ. Ventrum always punctured, with many narrow striæ.

TEGONOTUS Nal.— Dorsum of abdomen ridged and highly arched; striæ with toothlike projections on median. Ventrum flattened, punctured, with narrow striæ.

EPITRIMERUS Nal.— Abdomen behind shield broad with two longitudinal furrows on dorsum, highly arched. Striæ on dorsum narrow, numerous, smooth or punctured.

OXYPLEURITES Nal.— Few or all of striæ on dorsum with tooth or spine like projections on side. Abdomen much ridged or arched at the middle, with flattened sides. Shield large with anterior margin much extended.

CALLYNTROTUS Nal.— Dorsum of abdomen with longitudinal rows of short spine-like projections. Ventrum punctured, with narrow striæ.

PARAPHYTOPTUS Nal.— Dorsal and ventral striæ on anterior portion of abdomen similar. Posterior striæ on dorsum much broader. Anterior part of abdomen similar to Eriophyes, and posterior part resembling Phyllocoptes.

LIST OF AMERICAN SPECIES AND HOST PLANTS.

(1) *Eriophyes thujae* Garman.

Occurs on the leaves of the American arbor vitae, *Thuja occidentalis* L.

(2) *Eriophyes salicicola* Garman.

This mite thrives on the leaves of *Salix longifolia* Muhl., producing a narrow longitudinal upward fold, which extends down the entire length of the leaf.

(3) *Cecidobia* (?) *salicicola* Banks.

On willow from Colorado. The mite is responsible for galls which extend a little above both surfaces of the leaf.

(4) *Eriophyes querci* Garman.

Produces galls on the leaves of the bur-oak, *Quercus macrocarpa* Michx.

(5) *Eriophyes ulmi* Garman.

Produces galls on the leaves of the white elm, *Ulmus americana* L.

(6) *Eriophyes abnormis* Garman.

Found on the American linden or basswood, *Tilia americana* L., causing top-shaped galls on the leaves. The galls are similar to *Ceratoneon extensum* Bremi on *Tilia platyphyllos* Scop., produced by *Eriophyes tiliae* (Pgst.) Nal., which is common in Central Europe.

(7) *Eriophyes acericola* Garman.

Causes fusiform galls on the leaves of the sugar maple, *Acer saccharum* Marsh. The galls resemble *Ceratoneon vulgare* Bremi, produced by *Eriophyes macrorhynchus* Nal. on *Acer pseudoplatanus* L., growing in Europe.

(8) *Phyllocoptes quadripes* Shimer.

Produces spherical galls on the leaves of soft maple, *Acer saccharinum* L., and is a species of growing importance to shade trees. The galls are similar to *Cephaloneon solitarum* Bremi. In Central Europe *Eriophyes macrochelus* Nal. makes similar galls on *Acer campestre* L.

(9) *Eriophyes vitis* Landois.

Attacks the grape, *Vitis vinifera* L., and is a serious pest in Central Europe, Italy and California. It is responsible for *Phyllerium vitis* Fries. which occurs on grape foliage.

(10) *Eriophyes pyri* (Pgst.) Nal.

A common pest on the leaves of apple, *Pyrus malus* and pear, *Pyrus communis* L, in Europe and the United States.

(11) *Phyllocoptes schlechtendali* Nal.

On *Pyrus malus* L., and *Pyrus communis* L., in Central Europe and is very common on apple foliage in the United States.

(12) *Epitrimerus pyri* Nal.

On foliage of pear, *Pyrus communis* L., in Central Europe and the United States.

(13) *Eriophyes pruni* Schoene. (in MS.)

Produces galls on the leaves of the wild plum, *Prunus americana* Marsh. This species has been confused with *E. padi* Nal., but it differs from the latter in that the accessory setae are present. The galls are similar to *Ceratoneon attenuatum* Bremi, caused by *Eriophyes padi* Nal. on *Prunus padus* L.

(14) *Eriophyes phloeocoptes* Nal.

On *Prunus domestica* L., in Central Europe, Italy and the United States. The mites cause roundish galls at the base of buds and new growth. It is said to reduce the size of the fruit and crop production.

(15) *Phyllocoptes cornutus* Banks.

On peach, *Amygdalus persica* L. This species lives free on peach leaves and occurs in the Eastern States. The mite is said to produce a sort of a silvery sheen upon the leaf which is readily discernible when the light in shining on it.

(16) *Eriophyes fraxini* Garman.

Produces depressed wart-like galls on the leaves of the green ash, *Fraxinus viridis* Michx.

(17) *Eriophyes gossypii* Banks.

Found upon cotton in the West Indian Islands where it is very destructive. The mite causes galls which, when abundant, make the leaves unshapely. Severe infestation seriously affects the value of the cotton crop.

(18) *Eriophyes oleivorus* Ashmead.

Attacks the orange and the lemon and is a destructive pest of these fruits in Florida and California. It is popularly known as the rust mite because of the russetted appearance of the fruit, attending the injuries by the mite.

THE PEAR AND APPLE MITES.

The mites infesting apple and pear foliage were, with one exception, first recorded from Europe. Five species are there recognized thriving upon these fruits, which are *Eriophyes malinus* Nal., *Eriophyes pyri* (Pgst.) Nal., *Eriophyes pyri* var. *variolata* Nal., *Epitrimerus pyri* Nal., and *Phyllocoptes schlechtendali* Nal. Of this number *Eriophyes pyri* is regarded as the more important

species. In the study of the mites attacking apple and pear leaves in this State, all but *Eriophyes malinus* have been identified. *Eriophyes pyri* is the most abundant and is responsible for the recent conspicuous injuries to apple and pear foliage. *Epitrimerus pyri* and *Phyllocoptes schlectendali* have been quite numerous and appear to be more common here than on the Continent. The behavior of these two species in the future is a matter of interest as both seem to have possibilities of developing to greater economic importance. In addition to the above list of mites attacking pomes, another species, which is new and which has been designated *Eriophyes malifoliae*, is recorded for the first time. The known species of mites upon apple and pear may be separated by the accompanying table.

TABLE OF APPLE- AND PEAR-AFFECTING SPECIES OF MITES.

1	Number of dorsal and ventral striæ about equal	2
	Number of striæ on dorsum less than those on venter	5
2	Abdomen with about eighty striæ	3
	Abdomen with less than eighty striæ	4
3	Abdomen finely punctured	*Eriophyes pyri*
	Abdomen coarsely punctured	*Eriophyes pyri* var. *variolata*
4	Body vermiform, with fifty striæ	*Eriophyes malinus*
	Body abruptly acuminate, with about seventy striæ	*Eriophyes malifoliae*
5	Dorsum of abdomen with two longitudinal furrows	*Epitrimerus pyri*
	Dorsum of abdomen without furrows	*Phyllocoptes schlechtendali*

THE LEAF BLISTER-MITE.

ERIOPHYES PYRI (PGST.) NAL.

Phytoptus pyri. H. AL. PAGENSTECHER. *Verhandl. Naturhist. Med. Ver. Heidelberg.* 1:48. 1857.

Phytoptus pyri. NALEPA, A. *Anz. K. Akad. Wiss.* [*Vienna*], 26:162. 1889.

Phytoptus pyri. NALEPA, A. *Sitzber. K. Akad. Wiss.* [*Vienna*], 99:50. 1890.

Phytoptus arianus, Ph. cotoneastri, Ph. sorbi. CANESTRINI, G. *Atti Soc. Veneto-Trentina di Sci. Nat.* 12:16, 20, 21. 1890.

Phytoptus aroniae. CANESTRINI, G. Difesa dai Parassiti, 1:282, 1890.

Eriophyes piri. NALEPA, A. Das Tierreich, Acarina, Eriophyidae, p. 25. 1898.

SYSTEMATIC RELATIONSHIPS.

HISTORICAL.

In 1857, A. Scheuten[1] discovered that the pustular spots of pear leaves were due to the work of mites, but in common with other workers of his day, notably Duges, he drew some erroneous conclusions from the specimens of mites representing several species, taken from the pear leaves, which he had under observation. The blister-mite was considered by him as a larva, a gamasid which was a vagrant guest or was feeding on the blister-mite was believed to be the adult, and a hypopus was regarded as an intermediate form. Scheuten designated the supposed adult as *Typhlodromus pyri,* by which the blister-mite was known in literature for many years.

During the same year Pagenstecher[2] published some notes upon a number of mites, in which he merely mentions the leaf blister-mite and names it *Phytoptus pyri,* without giving a description. The mite was later studied by Nalepa[3] who in 1890 fully described and illustrated the external anatomy of it, which was the first adequate description of the species.

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[1] Scheuten, M. A. Troschel's Archives, 1857, p. 104:—His descriptions of the supposed stages of the mite are briefly as follows:

Larva.—A small white vermicle, 0.10–0.18 mill. in length and 0.025–0.040 mill. in breadth. Body covered with transverse striæ, which when highly magnified, prove to be firm, tubercular ribs, forming a strong shield. Animal with four short legs, inserted near rostrum. Body long, of uniform breadth with blunt termination, furnished with a pair of long undulated bristles. Between them are two smaller ones. Sides bear some bristles, which appear to support body in motion. Legs five-jointed, terminated by long nail or claw. Rostrum forms a truncated cone, containing sucking tube.

Intermediate form.— Similar to a mite, but much smaller, with four pairs of legs, the anterior forming stumps, the posterior styliform, terminating in two bristles.

Mite.— Form of mite oval, 0.30–0.34 mill. in length and 0.17–0.19 mill. in breadth. Mouth conical, acute and retractile. Palpi, five jointed, obtuse and strongly hairy, with apical joint set with bristles. Antennal jaws undistinguishable in living animals, but in glycerine preparations two clawlike jaws are seen. Palpi half-amalgamated with rostrum. Legs seven jointed, first pair distinctly longer than the rest, the two intermediate pairs shortest. Tarsal joint furnished with small funnel-shaped sucker which can be contracted, so as to appear like a simple claw on the first pair of legs, when employed in feeding.

[2] *Verhandl. Naturhist. Med. Ver. Heidelberg,* 1:48, 1857.

[3] *Sitzber. K. Akad. Wiss.* [*Vienna*], 99:50, 1890.

DESCRIPTIONS AND LIFE HISTORY.

DESCRIPTION OF LIFE STAGES.

Egg.— The egg is translucent and whitish. It is oval in shape, with bluntly rounded ends. The longer axis measures about 46 microns and the shorter axis is about 35 microns. The eggs are at least one week in hatching and the maximum number detected in one gall at the same time is fourteen. They may be found in the galls of the leaves from April to September. Oviposition also occurs in the buds. The eggs are deposited indiscriminately in the galls, at the base of the bud scales and in the pubescence of the buds.

Larva.—Length, 70 microns. The shield is smooth, with indistinct sculpturing. The striae of the abdomen are visible but are not apparent on the outline of the body. The punctuation is fine. The external genital parts are wanting. The legs are short and stout. The feathered hair has four rays and the claw is longer than the feathered hair. The caudal and accessory setae are of medium length. The lateral and ventral setae are of medium length and proportional to the size of the creature. The anal lobes are small. The larva is slightly active and exists in a rather curved position buried in the substance of the gall.

Adult.—The mite is usually white, with some individuals in each colony of a pinkish red color. The annulation and fine tubercles, which appear as minute punctures, are visible. Viewed dorsally, the lateral setae with basal tubercles are very prominent.

The body is cylindrical, annulated, gradually tapering to posterior segments. The cephalothorax is small and semicircular, sculpturing consisting principally of three irregular lines in median area, running from anterior to posterior margins. The rostrum is large, slightly curved and directed downward. The legs are strong and of rather even width, segment two being widest. The feathered hair is fine and inconspicuous, with four rays. The claw is small and slightly swollen at tip. Near distal end and outer margin of segment one, there is one long bristle, and a short one is on the opposite side. On segments two and four there is one short hair on outer margin. The epimera are quadrangular and rather long. Three pairs of thoracic setae are present. The third pair are longest and are situated in the basal portion of the second pair of epimera. The second pair of setae are somewhat shorter and are near

epimeral angle, being a little anterior of the third pair and nearer the sternal ridge. The first pair of thoracic setae are short and fine, and are near the base of the rostrum and just anterior of the second pair of setae.

The abdomen has about eighty rings. The tubercles are small, appearing, unless carefully focused, as chitinous rings. The anal lobes are of moderate size. Three pairs of ventral setae are present. The first pair are the longest and are slender. The second pair are very small and inconspicuous. The third pair of setae appear of the same thickness as the first pair but are not so long. The lateral setae are long and slender. The genital setae are slender but shorter than the lateral pair. The caudal setae are long, thick at the base, gradually tapering to the tip. The accessory caudal setae are short and thick. The epigynium is small and semicircular.

Specimens vary much in length. The average length of the females is from two to three hundred microns, and of the males from one hundred and sixty to one hundred and seventy-five microns.

LIFE HISTORY.

The winter is spent by the mites in the buds, preferably under the second and third layers of the bud scales. If the numbers are large they are often segregated into colonies, forming an entangled mass of fifty or more individuals in a depression or groove of the bud scale, more or less concealed by the pubescence. With the approach of warm weather in the spring the mites become active and may usually be seen in the greatest numbers toward the base of the growing bud scale where subsistence is obtained. Molting appears to take place about this time with many individuals of the colony, the cast skins being attached to the smooth portion at the top of the bud scale. As the buds burst there is a movement of the mites to the unfolded leaves in which the eggs are deposited. This migration takes place with the maturing of the bud scales during the latter part of April and early May, depending on the season, soon after which the discoloration of the leaves by pale and red colored spots occurs. The mites burrow through the epidermis of the underside of the leaf and feed upon the cellular tissue

on the interior. The irritation produced by these operations gives rise to a thickening of the leaf which is known as a gall or blister. Within these galls eggs are deposited, and the young find subsistence, channeling in all directions, and develop to maturity. Through the tiny openings in the under surface of the gall the adults pass to and fro, and seek other spots to produce fresh galls in which to start new colonies. The production of young and the migration of adults is continuous through the growing season, and in favorable years the numbers of the mites are sufficient to completely infest the unfolding leaves of the new growth as they appear. Mature mites are present in the leaf tissues during the first week of May, and from then on through September eggs and larvae are present in the leaves. During the latter part of May and the first of June the mites in greatly increased numbers may be found in the pubescence of the young wood, upon the leaf stems and upon the unfolding leaves of the new growth. During October the mites largely abandon the leaves and swell the numbers already in hiding in the buds and in the pubescence of the bark of the new wood. Hibernation occurs under the bud scales and apparently none of the mites pass the winter in the pubescence or in the crevices of the bark.

ECONOMIC IMPORTANCE.

The mite has largely attained its prominence as an orchard pest because of its destructive work on pear foliage. The literature upon this species is voluminous and it is almost entirely concerned with the economy of the mite in its relationship to pear growing. The references to the infestation of other plants are for the most part mere records of the host's name and give no suggestion of the probable importance of the injuries committed by the mite. The work of the species in this capacity seems to be of little consequence, for important outbreaks would not have escaped the attention of economic workers. As a pear pest it is undoubtedly well known wherever this kind of fruit is grown. As such it is recognized in Europe, Russia, England, Canada, United States, Australia and Tasmania, and there are without doubt other countries where it is present.

THE MITE AN IMPORTANT FRUIT PEST.

The mite was undoubtedly introduced at an early period into this country in foreign importations of nursery stock on either apple or pear trees and buds, and was probably well distributed in many fruit growing areas long before its presence was recognized. The first writer to direct attention to its appearance as an orchard pest in the United States was Mr. Townsend Glover,[1] Entomologist of the U. S. Dept. of Agriculture, who in May, 1872, received specimens of its work from a correspondent. Under his direction Mr. Thomas Taylor, microscopist, examined some of the pear leaves covered with dark brown blotches, which were said to be inhabited by myriads of small mites. The species was thought to be somewhat similar to the mite mentioned by Packard[2] as "the *Typhlodromus pyri* of Scheuten," known to infest pear trees in Europe.

Before the meeting of the American Association for the Advancement of Science held at Saratoga, N. Y., August 1879, Dr. W. S. Barnard[3] presented a paper on "bud blight insects," attributing the brown and black blotches of pear leaves to the activities of mites.

In 1880, Prof. Burrill[4] called attention to a widespread disease of pear leaves in Illinois and in the country at large which was ascribed to the work of the mite, *Phytoptus pyri.* He mentions the fact of the hibernation of the mites under bud scales, and their probable dissemination in scions and buds. For the protection of affected trees the removal of the one year old wood and its destruction by burning was suggested as a practical and efficient remedy.

In succeeding years the work of this species was recognized in many States and was given widespread mention. In 1883[5] the mite was observed in large numbers upon imported Russian pear trees in experimental nurseries in Iowa. By 1886, the work of this creature was known in Michigan, and that year Prof. C. P.

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[1] U. S. Dept. Agr. Rpt., 1872, p. 113.

[2] Packard's Guide, 1869.

[3] *Scientific American* (*Supplement No. 207*), p. 3302, Dec., 1879.

[4] *Gardener's Monthly,* **22**:18–19. Jan. 1880.

[5] Osborn, H., Iowa State Hort. Soc. Rpt., **18**:127–135, 1883. Ibid. Iowa Ag. Coll. Bull. 2, p. 56, 1884.

Gillette[1] suggested the use of strong soap suds, kerosene emulsion or sulphur during the dormant season as means of control likely to give efficient results. Profs. Bailey and Dudley[2] in 1890 recorded an abundant infestation by this pest in the pear orchards of New York. In the same year, Profs. Comstock and Slingerland[3] published the details of some interesting tests with kerosene emulsion to determine if applications to affected leaves would control mites. In this work only negative results were obtained. In the following year the presence of the pest was noted in Canada[4], Delaware[5], and Pennsylvania[6]. At the annual meeting of the Association of Economic Entomologists in 1892, Prof. Slingerland[7] reported that thorough spraying of dormant buds had proven an efficient remedy for the protection of pear trees. At this same meeting the pest was recorded in excessive abundance in the pear orchards of Eastern New York, Ohio, and New Jersey. In 1894 the mite was regarded as being generally distributed in the pear growing belts of Iraho,[8] California[9] and Oregon.

THE MITE AS AN APPLE PEST.

The mite has long been known to infest apple trees on the Continent but its work in this capacity in the United States is only of recent recognition. The pest has quite likely been present upon apple trees in New York for many years but important injuries by it were not brought to the Station's attention till 1902, when it was found to be very abundant in W. P. Rogers' orchard at Williamson. In 1903 the infestation of these trees was more conspicuous and attracted considerable attention from the fruit-growers in attendance at the summer meeting of the State Fruit-Growers'

[1] Gillette, C. P., Mich. Hort. Soc. Rpt., 16:87, 1886 (1887).
[2] N. Y. Cornell Sta. Bul. 19. Aug., 1890.
[3] N. Y. Cornell Sta. Bul. 23, p. 107. Dec., 1890.
[4] Fletcher, J., Can. Exp. Farms Rpt., 1891, pp. 198–200.
[5] Beckwith, M. H., Del. Exp. Sta. Rpt., 1891, pp. 89–90.
[6] Buckhout, Penn. Exp. Sta. Rpt., 1891 (1892), p. 182.
[7] *Insect Life*, 5:105. 1893.
[8] Ibid, 7:202. 1895.
[9] Ibid, 7:278. 1895.

Association, which was held in this village. Up to the present time its injurious numbers in this orchard have been maintained. During the same year Prof. M. V. Slingerland[1] observed through the central portion of the State numerous apple trees with many of their leaves showing the corky blisters characteristic of the work of this creature. The mites continued to increase in their economic importance and in 1905 marked infestation of many orchards in Wayne, Ontario, Monroe and Niagara counties was noted. In 1906 the mite was equally abundant in Livingston, Wyoming, Seneca and Yates Counties. In his apple orchard survey of Wayne County in 1903, Dr. G. F. Warren[2] recorded the presence of the mite in fifty-three orchards. It is stated that " the mites " were not bad in more than one-half of a dozen orchards, but in a few orchards some trees had practically every leaf affected." A like survey[3] of Orleans County in 1904 showed somewhat similar conditions of apple trees with respect to this pest. Of nineteen orchards showing mite injury, four were recorded as seriously infested, four considerably infested, and eleven slightly infested. The distribution of this species in other parts of this State, and other States, has not been determined, but it is quite likely that it will be found in many apple growing areas, for this past summer its presence was also detected in Illinois and Pennsylvania.

THE FOOD PLANTS OF THE BLISTER MITE.

The more common food plants of the blister mite are the pear, *Pyrus communis* L., and the apple, *Pyrus malus* L. Dr. Nalepa has also recorded this species on the foliage of the service-berry, *Amelanchier vulgaris* Mönch, the common cotoneaster, *Cotoneaster vulgaris* Lindl., the white beam tree, *Sorbus aria* Crantz., the European mountain ash, *Sorbus aucuparia* L., the wild service tree, *Sorbus torminalis* Crantz., and Dr. Rechinger has sent us specimens of the work of the mite on *Contoneaster tomentosa* Lindl., and *Sorbus mongeoti* Crantz., collected in Europe.

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[1] U. S. Dept. Agr., Ent., Bul. 46, p. 72. 1904.
[2] G. F. Warren, N. Y. Cornell Sta. Bul. 226, p. 340. 1905.
[3] Ibid. N. Y. Cornell Sta. Bul. 229, p. 489. 1905.

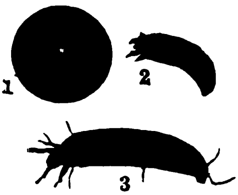

FIG. 1.—LIFE STAGES OF BLISTER-MITE:

1. Egg. 2. Larva. 3. Adult.
(Enlarged.)

FIG. 2.—PHOTOMICROGRAPHS OF APPLE AND PEAR MITES:

1. *Phyllocoptes schlechtendali. Epitrimerus pyri.*
3. *Eriophyes pyri.*

PLATE IX.

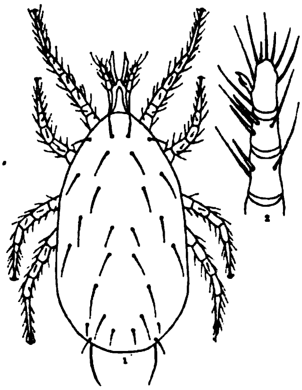

FIG. 3.— AN ENEMY OF THE BLISTER-MITE. (Enlarged.)
Seius pomi, n. sp.

FIG. 4.— LATERAL VIEW OF LEAF BLISTER-MITE.
(Greatly enlarged.)

PLATE X.

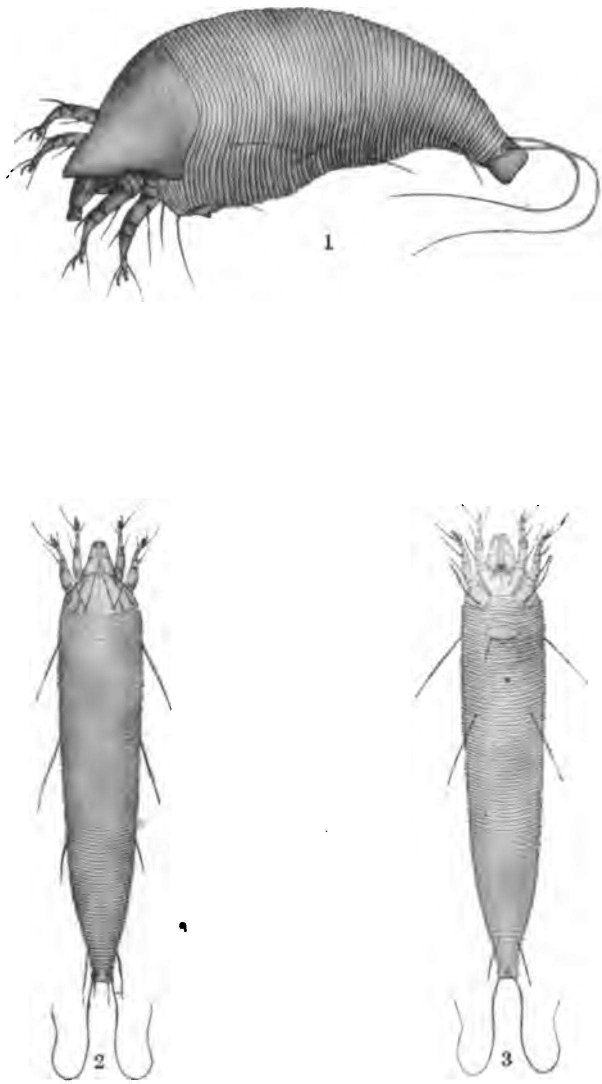

PLATE XI.— PEAR AND APPLE MITES:

1. *Eriophyes malifoliae* Parr.

2 and 3. *Eriophyes pyri* (Pgst.) Nal., after Nalepa.

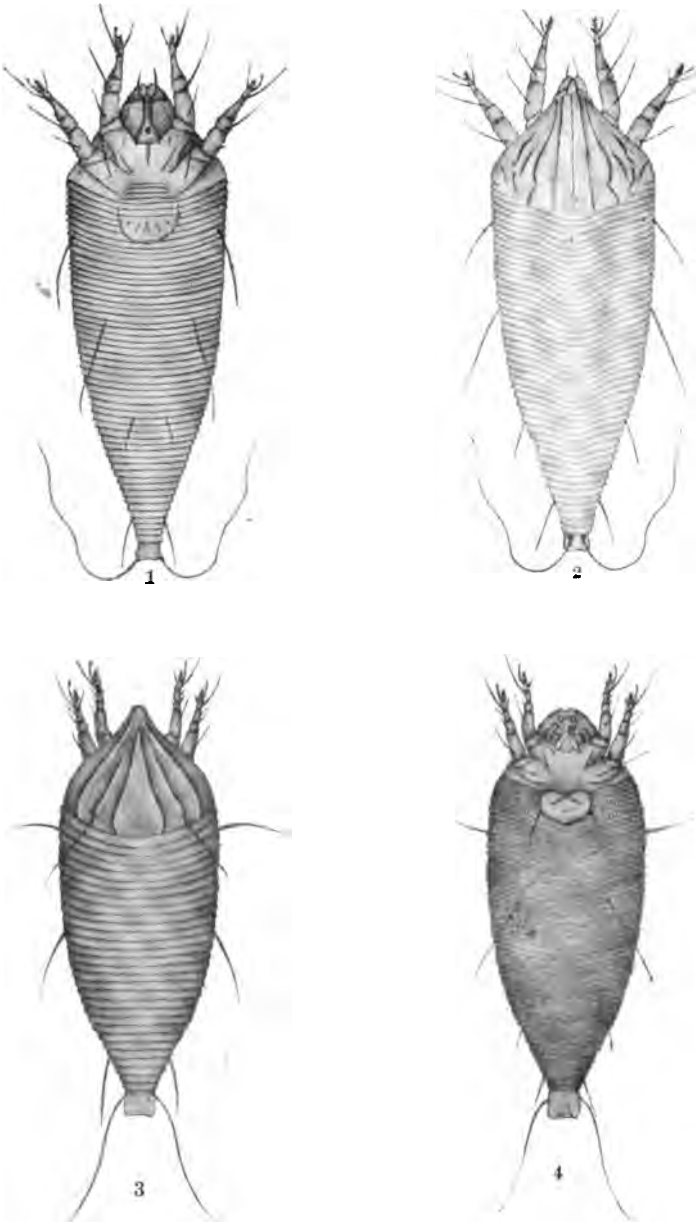

PLATE XII.— PEAR AND APPLE MITES:
1 and 2. *Epitrimerus pyri* Nal., after Nalepa.
3 and 4. *Phyllocoptes schlectendali* Nal.

PLATE I.—Pear Leaves Injured by the Leaf Blister-Mite.

PLATE VII.—YOUNG APPLES AND LEAVES SHOWING PIMPLES AND GALLS CAUSED B THE LEAF BLISTER-MITE.

PLATE III.—AN APPLE LEAF CLUSTER INJURED BY THE LEAF BLISTER-MITE

PLATE XIV.— PEAR FRUIT CLUSTERS SHOWING INJURIES BY THE LEAF BLISTER-MITE.

PLATE XV.—Other Host Plants of the Leaf Blister-Mite: 1. *Cotoneaster tomentosa* (Rechinger). 2. *Sorbus mongeoti* (Rechinger). 3. *Sorbus torminalis*. 4. *Sorbus aria*. 5. *Sorbus aucuparia*.

NATURE OF INJURIES TO FRUIT TREES.

Mite work on pear leaves.— The galls first appear as minute greenish pimples with a more or less reddish tinge, which are barely distinguishable from the leaf. With increase in size they become reddish, often causing brilliant colored spots on the leaves, and later, with the drying up of the diseased tissue, turn to a dark brown or black. On the under surface of the leaf, the affected areas are corky and raised, with the epidermis rather loose and wrinkled, suggestive of a blister, hence the popular name apple and pear blister to designate the work of the mite. Leading into each spot there is usually a tiny opening. The galls are irregular in shape, and vary in size, according to age, the largest being about one-eighth of an inch in diameter. Sometimes they lack red and differ little from the general color of the leaf. Some varieties of pear, especially the Keiffer, when much infested, have the unfolding leaves completely reddened, swollen and blistered, which, when unfolded, become much wrinkled and unshapely. The galls are usually arranged in a row on each side of the main rib. This grouping of the affected areas seems to be determined by the pubescence of the leaf and the condition of the leaf when unfolding, at the time of the migration of the mites from under the bud scales to the expanding leaf. When numerous, the spots may coalesce, forming dark brown or blackish patches of various sizes which may cover much of the leaf and cause it to rupture in one or more parts, especially along the margins. Severe infestation of the mites may cause more or less defoliation, resulting in the premature falling of the fruit from the most injured leaf clusters. The mites also cause light colored pimples about the calyx of the fruit and on the fruit stems, but these injuries are occasional and do not appear to impair the health or the value of the fruit.

Mite work on apple leaves.— The work of the mite on apple first shows on the upper surfaces of the leaf as distinct light colored pimples and on the undersides as blisters or thickened areas of the same color as the leaf. The affected areas are of irregular size and are unevenly distributed, though the larger proportion of them are about the sides and the base of the leaf. Some of the blisters may have a reddish tinge, somewhat similar to the pear leaf galls but ordinarily of a less brilliant color. As the galls become older they

appear as corky spots of a reddish brown color, which to the touch are very distinct from the healthy portions of the leaf. The individual galls average from one-twelfth to one-eighth of an inch in diameter and are usually oval or quadrangular in shape. Leading to the interior of each affected area there is usually one or more tiny openings. Often the spots coalesce, forming irregular dead areas, with a smooth or slightly raised surface and of a dark brown color, which rupture the leaf at the margins. Severe infestation seems to destroy the fresh color and gloss of the leaves and may cause them to be much wrinkled or to curve over, exhibiting the under surfaces.

About July 1 the most striking effects of the mites upon the leaves appear, especially if there is much yellowing of the foliage, as frequently occurs. Upon the upper surfaces of such leaves the mite-infested spots are of a light brown or of a dark green color and are uniformly brown beneath. These spots are thickly massed, forming a dark, broad band of irregular width along each side of the leaf which contrasts conspicuously with the intervening light yellow area about the main rib. To one standing on the ground and viewing the leaves from beneath, this striping of the leaves is very suggestive of variegated foliage of certain ornamental plants.

The mites also injure the fruits and the fruit stems. As a result of the attacks by the mites the young fruit soon after setting presents light green pimples, about one-eighth of an inch in diameter which stand out in marked contrast with the darker colored surface of the apple. These swellings are usually irregularly grouped about the calyx cavity. Apples that are half grown may show light, blister-like areas of one-quarter of an inch in diameter, suggestive of pock marks, which are variously distributed upon the surface, usually about the calyx cavity. These markings would ordinarily pass unnoticed and seem in no way to affect the value of the fruit. Injured apple stems show somewhat similar pimples of a smaller size. Severe infestation produces much thickened stems, which present a very irregular outline. In several instances the work of the mites upon the leaves and fruit stems of the same cluster has so weakened the stems as to cause the falling of the fruit. Premature dropping of the apples by this means seems to be of rare occurrence and even on the worst infested trees is not sufficient to appreciably affect crop production.

The work of the mite has been recognized on over two hundred and fifty varieties of apples. Some of the leading varieties sustaining severe injuries to the foliage are the Baldwin, Rhode Island *Greening,* Sutton, Fall Pippin, Ben Davis and King. The leaves of William Favorite in the Station orchard have been the worst affected and the trees have for two years shown marked unseasonable defoliation.

MITE INJURIES CONFUSED WITH SPRAY INJURIES.

Injuries by the mite and by spraying mixtures often appear upon the same leaf and have been much confused. The two are quite distinct and may be easily distinguished. Injuries due to treatment by the bordeaux-arsenical mixtures appear as dead brown spots of various sizes and shapes, and are irregularly distributed over the leaf surface. Frequently these spots are roundish or circular with a diameter of one-twelfth to one-eighth of an inch, while others are irregular in outline and much larger. Although the line of demarcation between the dead and living tissue is sharp, these spots are to the touch flat, often depressed, and are not in this manner distinguishable from the general surface of the leaf as are the mite-blisters. Spray-injured spots show the venation of the leaf which is seldom apparent in the mite galls, and the dead areas also lack the small hole leading to the interior, which is always present in the corky spots produced by mites.

MITE INJURIES CONFUSED WITH APPLE RUST.

In the Hudson Valley and Long Island, the rust is quite common and is often mistaken for the work of the blister mite. This disease may be distinguished by the presence of circular, orange-colored spots of one-quarter of an inch in diameter, which encircle dead brown irregular areas, and which are variously distributed over the leaf surface. Upon the undersides of the leaves the rust appears as brown calloused areas showing the characteristic cluster cups which are not present in the galls of the mite.

AN ENEMY OF THE BLISTER MITE.

The apple and pear blister mite is much subject to the ravages of a gamasid mite, *Seius pomi.* This was very abundant this season upon infested trees and undoubtedly materially assisted in reducing

the numbers of the blister mites. As it has apparently not been recognized before, it is briefly described as follows:

Seius pomi n. sp.— Length about four hundred microns and width two hundred and ten microns. Body ovoid and yellowish in color; dorsum with a number of bristles of varying size. First pair of legs are slender, coxa, femur, patella, and tibia are subequal in length, trochanter somewhat shorter but of equal width, tarsus is moderately long. Second, third and fourth pairs of legs are nearly equal in length and are stouter than the first pair. On all segments there are a number of fine hairs. The epistoma is projecting. The palpus is of medium length and is rather stout. The apical segment of palpus has on its inner margin near the middle a conspicuous bifid spine which is clawlike. The second segment from the apex has two stout spines on inner margin and the third segment has at least one stout spine on inner margin. All of the segments have a number of fine bristles, which are especially abundant on the apex of the last segment. (P. J. P.)

EXPERIMENTS IN CONTROLLING THE LEAF BLISTER-MITE.

ORCHARD I: PEARS.

This orchard is located at Northville. It consists entirely of Keiffer pears which are three years of age and of good size. The trees have been well cultivated and fertilized and each year cover crops have been grown. During the last year the trees grew rapidly, and the entire foliage of almost all of the new wood, for three or four feet from the tips of the shoots downward, was conspicuously marked by the work of the mites. The remarkable condition of the trees in this respect indicated an early infestation of the trees, which probably commenced with the insertion of the bud in the nursery.

Conditions:— The orchard was divided into two portions to make comparative tests of fall and spring spraying with the sulphur washes for the control of the mite. On December 1, 1904, thirty trees were sprayed with the self-boiled lime-sulphur wash, made after this formula: Lime 30 pounds, sulphur 15 pounds and caustic soda 5 pounds to 50 gallons of water. Twenty-three trees were treated with the boiled lime-sulphur wash consisting of lime 20

pounds, sulphur 15 pounds and salt 15 pounds to 50 gallons of water. On April 14, 1905, eleven trees were sprayed with the self-boiled wash. A few trees were left unsprayed to serve as checks.

Results on blister-mites: — In the spring of 1905 the trees were examined frequently by Mr. Sirrine to determine the effects of the treatment upon the trees and the mites. On March 27, he reported that a number of the fruit spurs on the trees sprayed with the self-boiled wash were dead, while the remaining trees, including the checks, sustained no apparent injuries. At this time the mites were abundant under the bud scales of the untreated trees while the sprayed trees showed little or no infestation. The mites were still present under the buds on April 20, but by the 24th they were migrating from their hibernating quarters to the unfolding leaves. Eggs were also detected under the bud scales. By April 30, some of the mites had burrowed their way into the unopened leaves, causing the usual reddish spots. There were no traces of mite injury upon the fall-treated trees but on the spring-sprayed trees there were a few affected leaves. The checks appeared in marked contrast with the treated trees as many of their leaves were much discolored and sometimes distorted by the work of the mite. May 4, eggs and mites were abundant on the unfolded leaves. Many galls were examined for larvæ and eggs without results, June 3. All the trees were badly infested with *Gymnosporangium* sp. which made it difficult to distinguish the blisters of the mites. The disease at this time seemed to be the more destructive. The condition of the trees with respect to infestation by the mite showed no apparent variation from former observations.

ORCHARD II: PEARS.

This orchard is located about three miles from Riverhead, Suffolk County. It consists of 130 Keiffer pear trees which have been planted two years. These have been given careful cultivation but have not been sprayed until the present experiment was conducted.

Conditions: — On April 8, 1904, twenty of the trees were sprayed with the self-boiled lime-sulphur-caustic soda wash, the remainder being reserved as checks. One application of the wash was made, which, on account of the small size of the trees, was very thorough.

Results on blister-mite.— On April 8, the leaves of the unsprayed trees were nearly all infested with the blister-mite while the sulphur-treated trees were apparently unaffectd. By May 16 there were a few leaves on four of the sprayed trees that showed slight traces of the mites but the remaining sulphur-treated trees showed no evidences of infestation. About June 25 the new growth of the checks was being attacked by the mites while the sprayed trees had clean foliage except in a few instances. A careful examination on August 1 showed that there were eight trees in the sprayed lot that had traces of mite work while the checks, without an exception, were well infested with the mites.

Results on pear trees.— The trees were uninjured by the treatment. The applications of the sulphur washes destroyed the lichens and left the bark clean. All foliage that had appeared after June 15 was still adhering on October 30, while the unsprayed trees were nearly bare. The leaves set before June 15 on both the sprayed and unsprayed trees were very much affected by leaf rust (*Gymnosporangium* sp.). Duchess and Seckel pears in the same orchard were free from this disease and also from the blister-mite.

Hand picking of infested leaves.— During the years 1903 and 1904, Mr. Sirrine conducted some experiments to determine the value of such treatment for the mite. On account of the small size of the trees this seemed a practical method of controlling the pest and was one that had been commonly recommended. During the last week in May, 1903, all infested leaves from five trees were removed and carried out of the orchard. One week later five more trees were treated in the same manner. An examination of these same trees on June 29 showed slight traces of infestation of the newly developed leaves. On May 16, 1904, these trees were carefully examined again when it was found that a number were abundantly infested. Later studies of the habits of the mite have shown that during the early summer the mites do not confine their operations entirely to the leaves as they may feed and breed in large numbers during the growing season upon the young forming buds and in the pubescence of the bark of the new growth. When the conditions are favorable for the rapid multiplication of the mites there is doubtless considerable migration of the mites from the older leaves to the new growth. The failure to control the mite by

the destruction of the infested leaves seems to be due to these habits of this creature. Nevertheless, the removal of affected leaves at the first appearance of injury would undoubtedly greatly reduce the numbers of the mite upon the plant. At the best this method of fighting the mite is only practicable upon small trees and from this experience it is not as effective as a thorough treatment during dormant season with a contact spray.

ORCHARD III: APPLES.

This orchard is adjacent to Williamson, Wayne County, and consists largely of Maiden Blush and Baldwin. The trees are about forty years of age and have been systematically sprayed for the common insects and diseases. Originally the orchard was grown in sod but in recent years thorough cultivation has been practiced. It is not known how long infestation with the mite has existed, but it is believed that the first serious outbreak occurred in 1902 when the Station's attention was first directed to the trouble.

On August 29 of that year, much of the foliage of a goodly number of the trees in the northeast corner of the orchard was well marked with the galls, many of which had coalesced, forming large dead, brown areas on the leaves. Associated with the work of the mite there was much spotting of the leaves by the bordeaux mixture. With some trees many leaves had turned yellow and were falling. This defoliation, coupled with the russeted appearance of a goodly portion of the leaves still adhering, due to mite and spray injuries, gave the trees a very unthrifty appearance.

In 1903, the state of the trees was less satisfactory than during the preceding year. The mite was more widely distributed through the orchard and the destruction of the leaves by spraying with bordeaux mixture was much more severe. Mite and spray injuries frequently occurred on the same leaf and there was the usual russeting, yellowing and falling of the leaves. While the mite was responsible for much of the discoloration of the leaves, the defoliation of the trees seemed to be due to spray injuries and to the unthriftiness of the trees, attributable to unfavorable soil conditions, which are not understood, probably poor drainage. By the end of the summer nearly every tree showed evidences of infestation, and a surprisingly large number of mites found hibernating quarters

in the buds, nearly all of which were tenanted. In 1904 the behavior of the orchard was quite similar to that of the previous year, except that injuries by spraying were not so marked. As there was no apparent decline in the numbers of the mite, and as it seemed to be an apple pest of increasing importance in this and other orchards, plans were made by which a number of the worst affected trees were secured for experimental purposes to determine satisfactory methods for treatment.

EXPERIMENTS IN 1905.

Conditions.— On May 2, treatment with whale-oil soap, one pound to five gallons of water, and kerosene emulsion, one part to eight parts of water, was commenced. The buds at this time were opening, and the mites were beginning to migrate from the bud scales to the unfolding leaves. One hundred and seventy trees, divided evenly between the two mixtures, were sprayed. Thirty-seven trees fully representative of the treated lot were reserved as checks. It was intended to apply the sprays much earlier than the date given, but successive rains and the condition of the orchard made this impossible. All the trees were given the three customary sprayings with the bordeaux-arsenical mixtures.

Results.— The trees were examined a number of times during the summer to ascertain the effects of the treatment on the mite. The conditions of the trees with respect to treatment by contact sprays are well shown by the following notes of July 21, which have been condensed: Checks are much infested with the mite. There is much yellowing and dropping of the leaves, and the trees are at least one-half defoliated. Apparently spray injuries from bordeaux treatment or some unfavorable soil conditions are responsible for this denudation. Trees sprayed with whale-oil soap show the work of the mite but the infestation is not quite as bad as with checks. Defoliation is severe. Trees sprayed with kerosene emulsion were slightly more exempt from mite injuries than those treated with the soap mixtures. Nearly one-half of the leaves had fallen to the ground and much of the foliage still adhering was turning yellow.

Summary.— The treatment for the blister-mite was not successful. The results may have been due partly or wholly to the pubescence of the buds which may have repelled the sprays or to the

lateness of the applications. Apple buds are more difficult to cover satisfactorily than pear buds. Besides at the time of treatment, the mites were active, and though none were discovered, it is quite probable that many were in the unfolded leaves, where they would be beyond the reach of the mixtures. The spraying seemed to furnish a small amount of protection to the trees but not enough to make the work profitable. The results obtained indicated the necessity of fall or early spring treatment if the pest is to be effectively controlled.

EXPERIMENTS OF 1906.

Conditions.— This year the applications were made earlier and special attention was given to the oil sprays. The same trees were used as in the previous experiment. On April 4, miscible oil, one part to twenty parts of water, kerosene emulsion, one part to eight parts of water, and whale-oil soap at the rate of one pound of soap to seven gallons of water, were each applied to four trees respectively. Pure kerosene oil was used on four trees. All the trees receiving treatment were drenched with the sprays. Five trees, similarly infested with the mite, were used as checks. The buds at this time were dormant. For purposes of comparison, the remainder of the orchard was treated on April 20, fifty-one trees being sprayed with whale-oil soap, thirty-four trees with kerosene emulsion, and fifty-one trees with miscible oil, the mixtures being used in the above strengths. The buds were well swollen. A short light rain followed the applications.

Results.— The operations in this orchard during this year gave the most satisfactory results of any of the various experiments undertaken to control the blister-mite upon apple trees. Derived as they are from a badly infested orchard of good size, the data obtained in this experiment have direct application to many orchards now infested with the mite. The results are briefly stated as follows:

Miscible oil.— The trees that received the early treatment were, throughout the summer, quite free of mite work, and the slight infestation that was present was largely confined to widely separated branches. The foliage was heavy, the trees having made a vigorous healthy growth. The three rows receiving the later ap-

plication were not quite so exempt from mites as the earlier-sprayed lot, but the condition of the trees was very satisfactory and surpassed that of the blocks contemporaneously sprayed with either kerosene emulsion or whale-oil soap. The cost of the spraying mixture for each tree was four cents.

Kerosene oil.— The trees sprayed with oil suffered a retardation of the leaf-buds, the effects of which were apparent for nearly one month after the appearance of the leaves on the checks. The amount of blossoming was small and none of the fruit set. One of the trees, which was much infested during the previous year, was entirely exempt from leaf galls. The remaining three trees showed slight traces of the mites which were due to obstructions in spraying. Since 1902 none of the trees in the entire orchard has shown so little evidence of the mites. These trees at the last examination on August 7 had made a thrifty growth and, with the exception of the loss of fruit, were in an excellent condition. The average cost of the oil for each tree was twenty cents.

Kerosene emulsion.— The trees receiving this treatment were more free from the mites than were the trees sprayed with whale-oil soap. The infestation was more abundant than existed in the blocks treated with miscible oil and pure kerosene oil. It was estimated that about 50 per ct. of the leaves were infested as compared with the checks. The applications of the kerosene emulsion caused no apparent injury to fruit and leaf buds and the fruit yields were fully as large as those of the checks. The cost of the emulsion for each tree was five cents.

Whale-oil soap.— The application of the whale-oil soap appeared to have had very little effect upon the mites; and the trees, with the exception of some of the lower branches, were fully as badly infested as the checks. The spraying in this case was just as thorough as the other treatments, and the only reasons that can be given for these results are that the soap was not used strong enough or that this spray is not adapted for penetrating the pubescence of the buds and the bud scales. The cost of the soap solution for each tree was five cents.

Conclusion.— In this year's work the mite was greatly reduced in numbers by several sprays, an accomplishment which was apparently due to early treatment and to the use of oil sprays which

are much more penetrating than the soap and sulphur preparations. While it is not so effective as the pure oil and the miscible oil, because of its safe qualities and its cheapness the kerosene emulsion seems to be the remedy best adapted to the needs of orchardists. Used a little stronger, at the rate of one part diluted with five parts of water, it is believed that still better results would be obtained. Pure kerosene oil and the miscible oils may be employed for the treatment of apples, suggestions for the use of which are given in the final directions for spraying for the mite.

GENERAL SUMMARY AND DISCUSSION OF RESULTS.

The leaf blister-mite passes the winter in the bud scales, usually of the buds of the new growth, and while in this situation is susceptible to practical methods of treatment. The protection derived from the buds makes the pest somewhat difficult to control because of the necessity of thorough spraying, but experience has shown that the mite may be effectually combated with but little more cost than is required for certain of the common destructive orchard insects. This is especially true of pears, which have uniformly given satisfactory results by spraying, but on the apple the mite is more difficult to control because of the size of the trees and the greater abundance of the pubescence of the buds which acts as more or less of a repellent to the spraying mixtures. Whale-oil soap mixtures and sulphur washes, which have proven very efficient in the treatment of pears, have been only partially effective upon apples, while the oils, pure or emulsified, and miscible oil, have given satisfactory results upon both kinds of fruits. In the experiments that have been undertaken upon them with apples, pure kerosene oil and crude petroleum, which are very penetrating and efficient insecticides, effected greater reduction in the numbers of the mites than any other of the various sprays that have been tested. But unfortunately these oils, unless used in the minimum quantities, are unsafe sprays, and may cause injuries to fruit and leaf buds, which limit their use to orchardists who have learned to apply them with safety, or to the treatment of trees on which more safe remedies have failed. While it is not quite so efficient as the clear oils, the kerosene emulsion appears to be the more practical remedy

for orchardists in the treatment of the mite. One application of the emulsion has controlled the mite on pear trees and has reduced the numbers of the mites on apple trees by one-half. It is besides a cheap and safe spray and for these reasons is better adapted to the needs of average fruit growers. If the infestation is severe, two sprayings with the emulsion are advised, one in the late fall and one in the early spring, during the period of November to March inclusive. If only one application is intended, this should be made in the fall if possible. Miscible oil gave very satisfactory results, and for use should be diluted with fifteen to twenty parts of water. Proprietary remedies are often variable in their insecticidal qualities, and one employing them should be fully alive to their limitations in this respect. The results obtained in these experiments suggest the following directions for the treatment of mite-infested apple and pear orchards respectively.

DIRECTIONS FOR COMBATING THE MITE.

On apple trees.— Spray the trees with kerosene emulsion diluted with five parts of water, the applications being made during the months of October, November, March or April. If possible, two sprayings should be made, one in the fall and one in the spring, as many mites are liable to escape with only one treatment. If it is not practicable to make more than one application, apply the mixture in the fall as soon as possible after the majority of the leaves have fallen, as many of the mites are still in the pubescence of the young wood, where they are more easily destroyed than under the bud scales. Special pains should be taken in the treatment of apple trees to wet the buds and the new growth thoroughly with the emulsion. Nothing less than a thorough drenching of the buds will give satisfactory results. The rough bark of the limbs and trunks may be neglected as they afford no protection to the mites. Miscible oil diluted with ten to fifteen parts of water may be used in place of the kerosene emulsion. Pure kerosene oil and crude petroleum are advised only when other sprays have failed. In using them they should be applied with the wind as a fine mist, spraying ceasing as soon as the oil commences to run on the bark.

How seriously an orchard should be infested before it is advisable to apply spraying mixtures is a question which the individual must determine for himself, as he is in a better position to watch the progress and to note the effects of the mite upon the foliage and to decide what are the probable results of the infestation upon fruit yields. From the observations that have been made upon the behavior of the mite in this State as an apple pest, it has been apparent that it varies in destructiveness in different orchards and in different years. This conduct of the mite appears to be due to the attacks of Gamasides, a group of closely related mites, which are its most formidable enemies. This is one of the hopeful features of the present invasion of the mites and should be given due weight in considering the advisability of spraying. Many orchards that are slightly infested may safely be allowed to run their chances for the present, recourse to treatment being taken upon the increase of the mite in sufficient numbers to affect the growth of the leaves and to cause their premature falling. But orchards that are overrun with mites should be sprayed. The leaves play an important role in determining the fruit yields, and trees that are subject to serious infestation of the leaves by the mite, accompanied by undue and unseasonable defoliation, such as has occurred during the past two years by the pest, would certainly produce smaller crops.

On pear trees.— The progress of the blister-mite upon pear trees may often be checked by simply pruning out and destroying by fire the infested twigs at the first appearance of injury. If the infestation is general the trees should be sprayed according to the directions given for the treatment of apples. Trees that are infested with the San José scale as well should be sprayed with the boiled lime sulphur wash which will control both the scale and the blister-mite.

ERIOPHYES PYRI VAR. *VARIOLATA* NAL.

Phytoptus piri var. *variolatus,* NALEPA, A., *Anz. K. Akad. Wiss.* [*Vienna*], **29**:16. 1892.

Eriophyes piri var. *variolata,* NALEPA, A., Das Tierreich, Acarina, Eriophyidæ, 1898, p. 25.

This differs from *Eriophyes pyri* by the very coarse punctuation of the abdomen. Specimens of this species were detected by Dr. Nalepa in microscopical mounts of *Eriophyes pyri,* collected from

apple leaves. In Europe it is known to infest *Sorbus aria* Crantz, *Sorbus aucuparia* L. and *Sorbus torminalis* Crantz. This species inhabits blisters upon leaves that are indistinguishable from those of *pyri*. It has been found only in few numbers and is much less important than the latter.

ERIOPHYES MALIFOLIAE n. sp.

The body is rounded on dorsum and is fusiform, being very broad posterior of the thoracic shield. The cephalothorax is large. The thoracic shield is large, because of the width of the body, and projects over the anterior margin of the body. Upon the median area of the shield there are a number of lines which extend from the anterior to the posterior margins. At the sides there is a rather indistinct netlike sculpturing. The thoracic setae are wanting. The rostrum is large, and is broad at the base.

The legs are rather long. The fourth and fifth segments are much narrower than the basal segments. The fourth segment is a little longer than the fifth segment. The third segment is a little over one-third the length of the second segment. The segments have the usual spines which are of medium size. The tarsal claw is of medium length and is knobbed. The feathered hair has four rays.

The abdomen is abruptly acuminate, with rather small anal lobes. The striae on dorsum number from sixty to seventy and are continued to the ventrum, where they are less widely separated. The ventral setae are fine and of medium length. The first pair are a little longer than the third pair, which are longer than the second pair. The lateral, genital and caudal setae are fine and of medium length. The accessory setae are wanting. The epigynium is large and projecting.

The female measures about two hundred microns in length and seventy microns in width.

This is a vagabond species and is found in association with *Eriophyes pyri* and *Phyllocoptes schlechtendali* upon the under surface of apple leaves. It is not as abundant as the two latter species but it is quite common in the apple orchards in the vicinity of Geneva and Canandaigua. (P. J. P.)

EPITRIMERUS PYRI, NAL.

Tegonotus piri. NALEPA, A., *Anz. K. Akad. Wiss.* [*Vienna*], 28:162. 1891.
Tegonotus piri. NALEPA, A., *N. Acta. Ac. Leop.*, 61:321. 1894.
Trimerus piri. NALEPA, A., *Anz. K. Akad. Wiss.* [*Vienna*], 29:155. 1892.
Epitrimerus piri. NALEPA, A., Das Tierreich, Acarina, Eriophyidae, p. 64. 1898.
Epitrimerus piri. PARROTT, P. J., *Science*, N. S., 23:73. 1906.

The anterior portion of the body is broad, with the abdomen abruptly acuminate, terminating in two broad caudal lobes. The striae on dorsum are few in number and broad. The thoracic shield is short, broad and triangular, with lateral angles often gently rounded and the anterior portion pointed and projecting over the head. On the median area of shield there are three nearly parallel lines which extend to almost the anterior and posterior margins. Laterad of these there are a number of short irregular linear markings. The dorsal setae are fine and short.

The legs are of medium size with tarsi much narrower than the other segments. The distal tarsal segment is shorter than the next tarsal segment. The feathered hair is small and has four rays. The tarsal claw is slightly knobbed and as is usual is longer than the feathered hair.

The abdomen is short and tapering, with a longitudinal furrow on either side of the median area or dorsum which is carinate. The striae on dorsum are about forty in number and are broad and punctured. The lateral setae are fine and of moderate length. The first pair of ventral setae are similar in form but are longer. The second pair of ventral setae are shorter than the first pair. The third pair of ventral setae are prominent, appearing to be a trifle stouter but somewhat shorter than the first pair. The caudal lobes are large, being short but broad. The caudal setae are of medium length and rather fine. The accessory caudal setae are apparently wanting. The epigynium is of medium size, with one pair of genital setae which are short and fine. Dr. Nalepa gives the length of the female as 150 microns and of the male, 130 microns. Of the many specimens which have been examined there has been much variation in the sizes of the mites which is perhaps determined by the differences in the ages of the individuals and the methods of

treatment in the preparation of mounts. The females in our mounts vary in size from 125–155 microns and the males 112–135 microns.

PHYLLOCOPTES SCHLECHTENDALI, NAL.

Phyllocoptes schlechtendali. NALEPA, A., *Anz. K. Akad. Wiss. [Vienna]*, **27**:2. 1890.

Phyllocoptes schlechtendali. NALEPA, A., *Sitzber K. Akad. Wiss. [Vienna]*, **99**:62. 1890.

Phyllocoptes schlechtendali. Von SCHLECHTENDAL, D. *Zeitschr. Pflanzenkrank,* **5**:5. 1895.

Phyllocoptes schlechtendali. NALEPA, A., Das Tierreich, Acarina, Eriophyidæ, p. 52. 1898.

Phyllocoptes schlechtendali. PARROTT, P. J., *Science,* N. S., **23**:73, 1906.

Body broadest at the posterior margin of the thoracic shield, with the abdomen gently acuminate. The striae on dorsum of abdomen are conspicuously coarse. The thoracic shield is large and broad, and projects over the anterior margin of the body. On median of the thoracic shield, extending from the anterior to the posterior margins are a number of somewhat wavy lines. Laterad of these there is a net-like sculpturing, which is more or less indistinct. The dorsal setae are of medium length. The legs are of medium size; segments two and three are the widest, and segments four and five are nearly equal in length. The segments have the customary spines. The tarsal claw is of medium length and is knobbed. The feathered hair has four rays.

The abdomen is broad and tapering. The striae on the dorsum are very coarse and are about thirty in number. The ventrum is finely annulated and coarsely punctured. The lateral setae are fine and of medium length. The first pair of ventral senae are similar to the lateral setae but are longer. The second pair of ventral setae are shorter. The third pair of ventral setae are of medium size and are shorter than the first pair. The genital setae are fine and of medium length. The caudal setae are of medium size. The accessory setae are wanting. The epigynium is small.

The female is one hundred and fifty microns long and fifty-three microns broad.

BIBLIOGRAPHY OF ERIOPHYES PYRI (PGST.) NAL.

Typhlodromus pyri. Scheuten, M. A. Troschel's *Arch.*, 1857, p. 104.
[Ibid, *Ann. Mag. Nat. Hist.*, 19:—. 1857.]

Phytoptus pyri. Pagenstecher, H. Al. *Verhandl. Naturhist. Med. Ver. Heidelberg*, 1:48. 1857.
Walsh, B. D. *Proc. Ent. Soc. Phil.*, 6:285–7. 1867.

Typhlodromus pyri. Packard, A. S. Guide, p. 666. 1869.
Glover, T. *Ent. Record*, 1872, pp. 304–307, fig. 10. July, 1872.
[Ibid, U. S. Dept. Agr. Mon. Rpt.]
Glover, T. U. S. Dept. Agr. Rpt., 1872, p. 113.
Thomas, F. A. W. Giebel's *Ztschr.*, 39:473. 1872.

Phytoptus pyri. Sorauer, P. *Versamml. Deut. Naturf. u. Aertze.* 1873, p. 133.

Typhlodromus pyri. Kaltenbach, J. H. Pflanzenfeinde, p. 204. 1874.

Phytoptus pyri. Sorauer, P. *Arb. d. Ver. Pom. Inst. Proskau*, 1877.

Typhlodromus pyri. Murray, A. Econ. Ent., pp. 340, 362. 1877.
Barnard, W. S. *Sci. Amer. Supplement*, No. 207, p. 3302. Dec. 20, 1879.

Phytoptus pyri. Burrill, T. J. *Gard. Mo. and Hort.*, 22:18–19. 1880; s. b., No. 22, pp. 177–178.
[Ibid. *Amer. Ent.*, n. s., 1:26. 1880.]

Typhlodromus pyri. Riley, C. V., and Fuller, A. S. *Amer. Ent.*, n. s., 1:26. Feb., 1880.
Ibid. 1:74. Mar., 1880.

Typhlodromus pyri. Taylor, T. *Gard. Mo.*, 22:85–86. 1880.

Phytoptus pyri. Taschenberg, E. L. Praktische Insekten-kunde, pt. 5, p. 158. 1880.
Frank, A. B. Die Krankheiten der Pflanzen, p. 699. 1880.
Garman, H. Rep. Ill. State Ent., 12:125, 140. 1882 (1883).
[Ibid, Trans. Dept. Agr. Ill., n. s., 13:125. 1882 (1883).]
Osborn, H. Iowa State Hort. Soc., Rpt., 18:127–135. 1883.
Osborn, H. Iowa Agr. Coll., Bul. 2, p. 56. 1884.
McMurrich, J. Johns Hopkins Univ. Circ., 14: No. 35, p. 17. 1884.
Hagen, H. *Can. Ent.*, 17:21–29, 1885.
Osborn, H., and Underwood, L. M. *Can. Ent.*, 18:12. 1886.

Typhlodromus pyri. Osborn, H., and Underwood, L. M. *Can. Ent.*, 18:12. 1886.

Phytoptus pyri. Crawford,—. Rept. on Fusicladiums, Aust. 1886. p. 46.
Sorauer, P. Pflanzenkrankheiten, pt. 1, p. 814. 1886.
Gillette, C. P. Ann. Rpt. State Hort. Soc. Mich., 16:87. 1886. (1887).
Webster, F. M. *Insect Life*, 1:363. 1889.

Phytoptus piri. Nalepa, A. *Anz. K. Akad. Wiss.* [*Vienna*], 16:162.
Nalepa, A. *Sitzber. K. Akad. Wiss.* [*Vienna*], 99:50, t. 4. f. 1, 2. 1890.

Phytoptus pyri. Ormerod, E. A. Ins. Inj. Orch. and Bush Fruits, p. 127, 1890.
Comstock, J. H., and Slingerland, M. V. N. Y. Cornell Sta. Bul. 23, pp. 103–107, 1890.
Lintner, J. A. *Country Gent.*, 55:781. Oct. 2, 1890.
Phytoptus arianus, Phy. cotoneastri, Phy. sorbi. Canestrini, G. *Atti Soc. Veneto Trent.*, 12:16, 20, 21. 1890.
Phytoptus aroniae. Canestrini, G. Difesa dai Parassiti, 1:282. 1890.
Phytoptus pyri. Weed, C. M. Insects and Insecticides, p. 68. 1891.
Beckwith, M. H. Del. Agl. Exp. Sta. Rpt., 1891, pp. 89–90.
Buckhout, W. G. Penn. Agl. Exp. Sta. Rpt., 1891, p. 182, (1892).
French, C. Destr. Ins. Vict., pt. 1, p. 119. 1891.
Fletcher, J. Can. Exp. Farms Rpt., 1891, pp. 198–200.
Fletcher, J. Can. Exp. Farms Rpt., 1892, p. 146.
Slingerland, M. V. *Insect Life*, 5:104–106. 1892.
Jolicoeur, H. Brochure V. Rheims. July, 1892.
Lintner, J. A. *Insect Life*, 5:105. 1892.
Webster, F. M. *Insect Life*, 5:105. 1892.
Smith, J. B. *Insect Life*, 5:105. 1892.
Fletcher, J. *Insect Life*, 5:125. 1892.
Smith, J. B. Rept. State Ent. N. J., 1892, pp. 389–512.
Phytoptus piri. Berlese, A. *Riv. Pat. Veg.*, 1:71–95. 1892.
Schöyen, W. M. Beretning om Skadeinsekter og Plantesygdomme, 1, 1895.
Phytoptus pyri. Canestrini, G. Pros. Acar. Italiana, pt. 5, pp. 589, 636, 706, 708. 1892.
Phytoptus cotoneastri. Canestrini, G. Pros. Acar. Italiana, pt. 5, pp. 638, 639. 1892.
Phytoptus arianus, Phy. sorbi. Canestrini, G. Pros. Acar. Italiana, pt. 5, p. 708. 1892.
Phytoptus pyri. McCarthy, G. N. C. Agl. Exp. Sta., Bul. 92, p. 99. 1893.
Slingerland, M. V. N. Y. Cornell Exp. Sta., Bul. 61, pp. 317–328. 1893.
Howard, L. O. *Insect Life*, 7:278. 1895.
Canestrini, G. Pros. Acar. Italiana, pt. 6, p. 802, 803. 1894.
Phytopus cotoneastri. Canestrini, G. Pros. Acar. Italiana, pt. 6, p. 775, 795, 806. 1894.
Phytoptus pyri. Lintner, J. A. N. Y. State Ent. Rpt., 10:453. 1895.
Sempers, F. W. Inj. Ins., p. 82. 1894.
Fletcher, J. Can. Exp. Farms Rpt., 1894, p. 199.
Washburn, F. L. Ore. Agl. Exp. Sta. Bul. 33, p. 16. 1894.
Ormerod, E. A. Rpt. on Insects and Grain Pests, 17:84. 1894.
Carpenter, G. H. Roy. Dub. Soc. Coun. Rpt., 1895, pp. 93–108.
Fletcher, J. Can. Exp. Farms Rpt., 1895, pp. 160–161.
Comstock, J. H. Manual, p. 44. 1895.

Sajo, Karl. *Ztschr. Pflanzenkrank.*, 5:31. 1895.
Ormerod, E. A. Inj. Insects, 18:86. 1895.
Gillette, C. P. Col. Agl. Exp. Sta. Rpt., 1896, p. 145.
Lodeman, E. G. The Spraying of Plants, p. 336. 1896.

Erineum pyrineum. Frank, A. B. Die Krankheiten der Pflanzen, p. 48. 1896.

Phytoptus pyri. Craw, A. 5th Bien. Rept. Cal. State Bd. Hort., 1895–6, p. 49.
Smith, J. B. N. J. Agl. Exp. Sta. Ann. Rpt., 1897, p. 407.
Schöyen, W. M. U. S. Dept. Agr. Ent. Bul. 9, n. s., pp. 79, 80. 1897.

Eriophyes piri. Nalepa, A. Das Tierreich, Acarina, Eriophyidae, p. 25. 1898.

Phytoptus pyri. Hedrick, U. P. Utah Agl. Exp. Sta., Bul. 55, p. 161, pl. 3, 4. 1898.
Felt, E. P. *Country Gent.*, 63:526. 1898.
Gillette, C. P. Col. Agl. Exp. Sta., Bul. 47, p. 20. 1898.
Sanderson, E. D. *Farm, Field and Fireside*, 14 Jan., 1899.
Sanderson, E. D. *Green's Fruit Grower*, Aug., 1899.
Garman, H. Ky. Agl. Exp. Sta., Bul. 80, pp. 245–247. 1899.
Cockerell, T. D. A. Ariz. Agl. Exp. Sta., Bul. 32, p. 294. 1899.
Lowe, V. H. N. Y. Agr. Exp. Sta., Bul. 170, p. 425. 1899. [Ibid. revision, 1903.]
Slingerland, M. V. *Rural New Yorker*, 58:592. Aug., 1899.
Craw, A. *Cal. Cultivator*, 15:72–73. Feb., 1900.
Fletcher, J. Can. Expt. Farms Rpt. 1900, p. 240.
Cook, A. J. *Rural California*, 23: No. 3. Mar., 1900.
Cockerell, T. D. A. Ariz. Agr. Exp. Sta., Bul. 34, pp. 82–84. June, 1900.
Close, C. P. Utah Agl. Exp. Sta., Bul. 65, pp. 75–76. 1900.
Cooley, R. A. Mont. Agl. Exp. Sta., Bul. 23, pp. 100–102. 1900.

Phytoptus pyri. Wickson, E. J. *Pacific Rural Press*, 61:339. 16 Nov. 1901.
Pierce, N. B. U. S. Dept. Agr., Veg. Pathol., Bul. 20, p. 180. 1900.

Eriophyes pyri. Forbes, S. A. Ill. Agl. Exp. Sta. Circ. 36, p. 43, fig. 33. July, 1901.
Ibid, Trans. Ill. Hort. Soc., n. s., 36:142–154. 1901 (1902). (22nd Rpt. Ill. State Ent.)

Eriophyes piri. Connold, E. T. Br. Veg. Galls, p. 150, pl. 59. 1902.
Piper, C. V. U. S. Dept. Agr., Farmer's Bul. 153, pp. 9, 31. June, 1902.

Phytoptus pyri. Gillette, C. P. Colo. Agl. Exp. Sta., Bul. 71, p. 40, fig. 27. 1902.
Gillette, C. P. Col. State Bd. Hort. Ann. Rpt., 1901, pp. 55–77, figs. 21. 1902.
Wickson, E. J. *Pacific Rural Press*, 63:295. May 3, 1902.
Forbes, S. A. Twenty-second Ann. Rept. Ill. State Ent., 1903, p. 149.

Phytoptus pyri. Cooley, R. A. Mont. Agl. Exp. Sta., Bul. 51, pp. 228–231. 1903.
Washburn, F. L. Minn. Agl. Exp. Sta., Bul. 84, p. 93. 1903. [Ibid, 8th Ann. Rept. St. Ent., 1903].
Wickson, E. J. *Pacific Rural Press,* 65:2. July 4, 1903.
Sherman, J. F. N. C. Agl. Exp. Sta., Bul. 183, pp. 45–63. 1903.
Slingerland, M. V. U. S. Dept. Agr. Ent., Bul. 46, pp. 69–73, 1 pl., 1904.
Pettit, R. H. Mich. Agl. Exp. Sta., Sp. Bul. 24, p. 60. 1904
Wickson, E. J. *Pacific Rural Press,* 67:3. July 25, 1904.
Eriophyes pyri. Banks, N. Proc. U. S. Nat. Museum, 28:104. 1904.
Phytoptus pyri. Parrott, P .J., Beach, S. A., Sirrine, F. A. N. Y. Agl. Exp. Sta., Bul. 262, pp. 39, 43, 67. 1905.
Warren, G. F. N. Y. Cornell Exp. Sta., Bul. 226, pp. 334. 340, Bul. 227, p. 434. 1905.
Eriophyes piri. Parrott, P. J. *Science,* 23:73. 1906. Proc. West. N. Y. Hort. Soc., 1906, p. 76.

REPORT

OF THE

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REPORT OF THE HORTICULTURAL DEPARTMENT.

VARIETIES OF APPLES FOR NEW YORK.*

U. P. HEDRICK, N. O. BOOTH AND O. M. TAYLOR.

"What varieties shall I plant?" There is no question more often asked by fruit growers. Vast amounts of time and money are wasted in the indiscriminate testing of varieties. For most part in the apple industry the value of varieties has had to be determined by actual plantings made by the fruit grower. It requires a long period of years to test apples and with the many sorts offered, individual efforts in this direction are ineffectual, and are most burdensome. So the work of testing varieties has been largely, and rightfully, delegated to the experiment stations. But it is impossible for an experiment station, even after the most careful tests on its own grounds, to tell in advance what particular varieties of a fruit are adapted to any one man's conditions. An experiment station can be helpful in this respect only by a broad and careful study of the distribution and behavior of varieties under as many different conditions as possible, and by an intimate first hand knowledge of them on its own grounds, after which it ought to be able at least to limit the choice in any locality.

It is the purpose of this bulletin: First, to catalogue the apples that are grown or have originated in New York. Second, to describe briefly the sorts listed. Third, to define the several distinct horticultural belts in the State and to name the varieties of apples that can be most successfully grown in each. It is hoped that the bulletin will serve as a guide to those who are planting

*A reprint of Bulletin No. 275.

apples and in particular that it will in part prevent the enormous waste occasioned by continued attempts on the part of the apple-grower to grow varieties which are not adapted to the regions in which they are planted. The Bulletin answers, as best this Station can, the oft asked question — "What varieties of apples shall I plant?"

The basis of what is here presented is Beach's "The Apples of New York" prepared by this Station and published by the State Department of Agriculture. The condensed descriptions are taken from the above work as nearly verbatim as the condensed form would allow. The notes in the column of remarks, to which attention is called as being one of the most valuable features of the Bulletin, are either taken word for word or are direct inferences from the text. Much of the material for "The Apples of New York" was obtained through correspondence with apple growers in all parts of the State. Much information that was given by correspondents in regard to the adaptations and distribution of varieties could not be used in the larger work. This is being made use of in this bulletin, in making up the list of varieties for the several regions outlined.

THE DISTRIBUTION OF VARIETIES OF APPLES.

Plants naturally grow in communities. Forests illustrate this. Several species having common necessities grow together. But in such an association one species is usually most prominent and gives its name to a community — oak forests, beech, maple, pine and walnut forests, and so on. The natural distribution of one or a few species of plants in these communities is suggestive to the plant grower. It signifies that Nature governs the distribution of all plants, wild or domesticated, according to their vital necessities; it justifies the presumption that for each species of plants there is a set of conditions best suited to it.

In agriculture it has come to be a matter of common knowledge that success with any crop depends largely upon its being grown in an environment preeminently well suited to it. Distinct classes of farming land, or distinct sets of conditions, are being devoted, more and more, to special crops. It is true, however,

that some plants of widely different species have similar needs and that now and then several crops may grow equally well on a farm in association or in a rotation. What is true of the adaptations of species is to a lesser degree true of varieties and these have their likes and dislikes of environment which may be quite different for any two varieties; or, for some one sort may be quite opposed to those of the species as a whole. Thus one variety of a crop may and often does grow in a region almost to the exclusion of all others; as the Concord grape, the Baldwin apple and the Bartlett pear in parts of New York. These adaptations are so marked that lists of plants and of their varieties can be made which thrive or do not thrive in any region. Such lists should be valuable guides in the selection of varieties.

In a very general way it may be said that a variety is adapted to regions having about the same latitude. We do not usually expect that northern varieties will succeed in the South or Southwest, nor the reverse. Thus New York apples are for most part of local or of New England origin. This adaptation to latitude seems to be caused by length of season rather than the degree of heat or cold. Some southern varieties, as the Ben Davis and the York Imperial and others, are as hardy as the great majority of the northern varieties, but the seasons in the North are not sufficiently long for the fruit to mature. On the other hand the King, Northern Spy, and most other northern sorts find the southern season too long and because of it quickly pass through maturity to decay. There are of course exceptions to this law of adaptability of varieties to regions of the same latitude, best known of which are some of the Russian varieties, as Red Astrachan, Yellow Transparent and Oldenburg, which succeed in both the North and the South.

The New York apple grower is warranted in taking a very conservative attitude in regard to all varieties from the South and Southwest. Among the many sorts grown commercially in the great apple region of the Southwest, the Ben Davis is the only one which is being grown by the commercial apple grower of New York and even this sort grows much better in the South.

Another important fact to the fruit grower is that there are groups of apples the members of which have about the same degree

of suitability to a region. It is worth while to consider these groups, their formation and adaptations, somewhat more closely than we have done with the varieties.

THE ADAPTATIONS OF GROUPS OF APPLES.

Our varieties of apples have descended from the wild apple. That the apple now varies, sometimes in one direction and sometimes in another, can not be denied; and so it has done since the first apple. Now, variations eventually mean varieties. Thus we have come to have a great number of varieties of apples, 714 of which are described in this bulletin. But the differences or gradations between varieties are not equal. Many varieties closely resemble each other while the differences between others are so great that they might almost belong to different species. There are, too, many missing grades. By recognizing these unequal degrees of likeness we may divide our cultivated varieties of apples into natural groups putting those which resemble each other together. Such a classification ought to become a formulation of varieties into groups in accordance with their blood relationships in the descent from the common ancestor.

Botanical classification has searched out the relationships which the structure of the apple plant and fruit indicate and has expressed them by dividing the apple into several large groups, *species*. It is the office of pomological classification to subdivide such of these botanical species as are of value to the cultivator into smaller groups for the greater convenience of the pomologist. Chief of the species with which the fruit-grower is concerned is *Pyrus malus* composed of a thousand or more of our best known varieties. As has been said, many of these varieties greatly resemble each other and these may be put together in large groups, as the Fameuse, Baldwin, Ben Davis, Oldenburg, and Winesap groups. Or, in some cases, the variety may be subdivided; thus we have distinct strains of the Baldwin, the Twenty Ounce, the Gravenstein, the Fameuse and the Wealthy.

It is worth remembering as an indication of the present trend of pomology that when the domestication of plants began, interest centered entirely around the species. There were no varieties

nor other groups within the species. People in countries but little advanced in horticulture still give attention to the species and wholly or largely ignore the variety. But as cultivation of plants has advanced and as we have come to know them better, groups within the species have come to be recognized. Smaller groups are now designated by names. While at present the variety is the commonest subdivision of the species yet as our ideas become more refined we shall make more use of still other divisions, as the *group,* higher than the variety, and the *strain,* lower.

But the chief point to be brought out in this discussion is that *groups of varieties have adaptations to particular conditions.* Thus there are groups of apples for certain geographical regions; as the Winesap, Romanite, and Ben Davis groups for the southern apple regions; the Fameuse, Blue Pearmain and Baldwin groups for New York; and the crab-hybrid group, represented by the Wealthy, and the Russian groups for the North Mississippi Valley. This development of groups of varieties for regions having diverse conditions is becoming more and more marked, and cognizance of it must be taken in preparing lists for the several pomological districts of New York. We shall find it of great advantage to discard whole groups of apples from certain districts or even from the State itself. It is time, too, to emphasize the importance to the fruit-grower and to the nurseryman of considering varieties of our fruits in their natural groups whether for propagation, distribution, culture, marketing, or whatever purpose.

Before proceeding to a direct application of this matter of grouping to the subject in hand another phase of it is worth setting forth. Varieties which belong to the largest and best differentiated groups have their characters most strongly fixed and are prepotent in transmitting them to their offspring. Thus seedlings of the Ben Davis, Fameuse, or Russian groups come nearly true from seed; the varieties of these, and of all cosmopolitan groups, are adapted to many diverse conditions; the plant-breeder finds them more plastic subjects for his work; and, withal, the size of the group, the number of varieties in it, is an indication of merit in a number of minor respects but in particular that it indicates potency and power of adaptation. Similarly we shall find upon close analysis

that the above points of merit are to be found in varying degrees in varieties which have strains within themselves.

New York apple growers are not wholly unacquainted with the arrangement of apples in groups. In "The Apples of New York" (1903), Beach has made 12 groups containing 54 varieties; at the State fair at Syracuse (1905), The New York State Fruit Growers' Association showed 14 groups with about 60 varieties. This Station has shown at the several State horticultural meetings of the winter of 1905–06, 32 groups with about 110 varieties. All of these lists have been worked over and added to in making the groups presented here, 36 in number and containing 278 varieties. Mr. L. A. Goodman, President of the American Pomological Society, is largely responsible for the Romanite, Ralls and Winesap groups given here.

It cannot be hoped that the groups given are all perfect. Without question some varieties have been misplaced, some have been omitted, and we have not even attempted to classify the great majority of the sorts listed in the catalogue, having no fruits at hand nor definite data from which to work. Besides it is scarcely possible that a wholly satisfactory classification can ever be made because of the infinite variation in the varieties themselves. The groups must be taken, then, as tentative, subject to modification upon further study, and presented here only as a means of showing the adaptations of varieties rather than as a part of a system of classification.

The groups are founded, for most part, upon the characters of the fruits, and all characters have been considered — size, form, stem, cavity, basin, calyx, color, skin, flesh, core, seeds, flavor and season. It has not been possible to make much use of tree characters, though, could it have been done, it would have been highly desirable. In giving a name to a group we have in most cases used that of the best known variety in the group, though in a few instances the name given is that of the variety which seemed to be intermediate in character between the other members of the group.

GROUPS OF APPLES.

APORT GROUP.

Large, handsome, fall apples, coarse in texture and of medium quality. Some members of the group are adapted to all parts of New York.

Alexander,	Bismarck,	Judson,
Aport,	Constantine,	McMahon,
Aport Orient,	Great Mogul,	Thompson,
Arabskoe,	Howard Best,	Wolf River.
Bietigheimer,		

BALDWIN GROUP.

Highly colored, long keeping, well flavored, rather large apples with similarities in texture, flavor, form and color markings. Trees winterkill in the northern districts but are well adapted to all other districts.

Babbitt,	Olympia,	Sutton,
Baldwin,	Red Russet,	Tufts.

BEN DAVIS GROUP.

Rather large, bright red, coarse and solid in texture, indifferent flavor, thick skin, shipping well and keeping well.

Arkansas Beauty,	Dickinson,	Gano,
Arkansas Belle,	Eicke,	Shackleford,
Ben Davis,	Etris,	Shirley,
Black Ben Davis,	Florence,	Wallace Howard.
Coffelt,		

BLACK GILLIFLOWER GROUP.

Medium size, dark red, oblong, ribbed apples of good quality but rather dry and coarse in texture. Less hardy than the Baldwin group. Particular as to soils.

Black Gilliflower,	Scollop Gilliflower,	Striped Gilliflower.
Lady Finger,	Skelton,	

BLUE PEARMAIN GROUP.

Somewhat large, dull red with bluish bloom, mild flavor, fair quality, dense texture and thick skins. Adapted to northern conditions and for most part valuable there only.

Baxter,	Jewett *Red*,	Rutledge,
Bethel,	Mabie,	Scarlet Beauty,
Blue Pearmain,	Monroe Sweet,	Stone,
Du Bois,	Oel Austin,	Victoria,
Gideon Sweet,	Perry,	Windsor.

CHENANGO GROUP.

Medium size, striped red, oblong conic apples of high quality, peculiar aroma and delicate texture. In general the two sorts in this group succeed where the Baldwin can be grown.

Chenango,	Stump.

EARLY HARVEST GROUP.

Summer apples of medium size, pale yellow or white in color, of good but not superior quality and with delicate breaking flesh. More suitable to the warmer than to the colder portion of the State.

Cooper Early White,	Early Harvest,	Parry White.

FAMEUSE GROUP.

Medium size, handsome red striped apples, roundish oblate, thin skinned, of high dessert quality, and pure white tender flesh. Its tendency to reproduce true from seed is a striking peculiarity. As a group, predisposed to fungus troubles. The varieties in this group, with one or two exceptions, reach their highest perfection in the North. The most valuable group for the colder portion of the State.

Boys Delight,	Louise,	Scarlet Pippin,
Canada Baldwin,	La Victoire,	Shiawassee.
Fameuse,	McIntosh,	Striped Fameuse.
Fameuse No. 1,	St. Lawrence,	Switzer.
Hilaire,		

HIBERNAL GROUP.

Probably the hardiest apples. Mature in a short season. Russian.

Bogdanoff Glass,	Ostrakoff,	Romna,
Hibernal.		

JONATHAN GROUP.

Medium size, handsome red apples of high quality, and crisp, juicy flesh. Variable in adaptations. Resembles the Baldwin

group. With one or two exceptions best adapted to the Eastern districts.

Esopus *Spitzenburg*,	Kaighn,	Mother,
Flushing *Spitzenburg*,	Manchester,	Red Canada.
Jonathan,		

KESWICK GROUP.

English apples of unknown adaptations in New York.

Keswick,	Lord Suffield.

LADY GROUP.

Very small, roundish oblate, dessert apples, handsome in color and sprightly in quality, crisp, juicy flesh, thin skin, and good keeping qualities. Best adapted to the Hudson Valley and Long Island districts.

Black Lady,	Lady,	Sleight,
Helen,	Large Lady,	Star Lady.
Highland Beauty,	Rose Colored Lady,	

LAWVER GROUP.

Medium size, very high color, of rather dense, medium coarse texture and inferior flavor. Excellent keepers. From the South, but Akin, at least, is worth trying in the milder parts of New York.

Akin,	Lawver,	McAfee.

LIMBERTWIG GROUP.

From the Southwest and not adapted to New York conditions.

Green Limbertwig,	Red Limbertwig.

LONGFIELD GROUP.

Russian, and can be grown in practically all parts of New York.

English Pippin,	Longfield.

LOWLAND RASPBERRY GROUP.

Russian. Adaptation not well known in New York. Probably northern.

Lowland Raspberry,	Red Wine,

NEWTOWN SPITZENBURG GROUP.

Medium sized roundish, striped apples of high quality. Running small in New York and not well adapted to any of our districts.

Bethlehemite,	Duncan,	Newtown Spitzenburg.

NORTHERN SPY GROUP.

Large, striped red, roundish oblate, ribbed, delicate bloom, juicy, crisp, fine grain, of highest flavor and quality. Fastidious as to soils but probably can be grown in congenial locations in all but the coldest portions of the State.

Arnold,	Melon,	Stanard,
Doctor,	Northern Spy,	Wagener,
Hagloe,	Ontario,	Wagener Improved.

OLDENBURG GROUP.

Medium to above in size, variously striped with red, generally ripening in fall and of comparatively short season. Tart, culinary apples with but few dessert sorts. Russian. Probably the most cosmopolitan of the groups here listed — some members succeeding in all parts of New York.

Ananarnoe,	Falix,	Milwaukee,
Autumn Streaked,	Gladstone,	Okabena,
Berkoff,	Glass Green,	Oldenburg,
Borovinka,	Golden White (Pewaukee type),	Pewaukee,
Champagne,	Hoadley,	Striped Winter,
Charlamoff,	Lead,	Yahmke,
Crimean (Pewaukee type),	Lou,	Zettle.
Dudley,		

GRAVENSTEIN SECTION.

Banks,	Gravenstein.

RALLS GROUP.

On mature trees only medium to below in size, rather dull striped red, of superior quality and texture, keeping late, productive to a fault. A southern group not adapted to northern conditions.

Doctor Walker,	Father Abram,	Ralls,
Ingram,	Milam,	Salome.

RAMBO GROUP.

Only medium in size, roundish oblate, rather dull striped red, good quality. Southern. Adaptations not well known for New

York, though some members of the group can be grown in the warmer districts of the State.

Domine,	Milden,	Rambo,
Lacker,	Pennsylvania Redstreak,	Wells.

RED ASTRACHAN GROUP.

Summer apples of above medium size, crisp, tart and of good quality. May be grown in all parts of the State.

Anis,	Red Astrachan,	White Astrachan.

REINETTE GROUP.

With few exceptions rather large in size, of green or yellow ground color, with or without blush, and generally of good quality. A large and poorly defined group which is here divided into four sections. Nearly all of the members, with the exception of a few in the Newtown Section, thrive in New York. Only a few varieties of this group, however, succeed in the northern district.

FALL PIPPIN SECTION.

Albion,	Greenville,	Newark Pippin,
Boiken,	Hawley,	Ohio Pippin,
Crowns,	Holland Pippin,	Reinette Pippin,
Ewalt,	Jack,	Sharp,
Elgin Pippin,	Landsberg,	Walker Beauty,
Fall Harvey,	Lehigh *Greening*,	White Pippin,
Fall Pippin,	Lowell,	White Spanish Reinette.
French Pippin,	Magenta,	Winter Banana,
Geneva Pippin,	Maiden Blush,	York Pippin.
(1) Golden Pippin,		

RHODE ISLAND GREENING SECTION.

Autumn Swaar,	Monmouth,	Sheddan,
Bottle Greening,	Northwestern *Greening*,	Starr,
Canada Reinette,	Patten,	Sweet Greening,
Fall Orange,	Rhode Island *Greening*.	Tobias Pippin.
Holland Winter,		

NEWTOWN SECTION.

Admirable,	Huntsman,	Pickard Reserve,
Belmont,	Middle,	(I) Shannon,
Green Newtown,	Peck *Pleasant*,	Slingerland,
Grimes,	Perry Russet,	Yellow Newtown.

SWAAR SECTION.

Mann,	Seneca Favorite,	Swaar.

ROMANITE GROUP.

Variable in size, highly colored, from poor to good in quality, keeping very late. Southern apples of little value in New York with the possible exception of one or two sorts for the warmer districts.

Buckingham,	Lansingburg,	Pennock,
Fink,	Minkler,	Romanite,
Gilpin,	Missing Link,	Stark,
Glenlock,	Nero,	York Imperial.

ROME GROUP.

Above medium, roundish, handsomely colored apples of indifferent quality. Rome only succeeding in some parts of New York.

Lankford,	Rome.

RUSSET GROUP.

Ranging from small to above medium in size, russet colored, with peculiarly fine-grained dense texture, sprightly flavor and good keeping quality. Illy defined as to adaptations but some member succeeding in all of the New York districts.

Brownlees,	Golden Russet (of W.N. Y.),	Roxbury,
Bullock,	Hunt Russet,	Sailee Russet,
Carpentin,	Long Island Russet,	Swazie,
English Russet,	Pomme Grise,	Sweet Russet.

SUMMER RAMBO GROUP.

Large, attractively striped with red, roundish oblate, coarse in texture, and of average quality, ripening in early fall. Adaptations not well defined for New York.

Grosh,	Summer Rambo,	Western Beauty.

SWEET BOUGH GROUP.

Summer or fall apples of sweet flavor, medium to large size, variably conic, good quality. Very general in adaptations, although some of the members cannot be grown in cold localities.

Autumn Bough,	Fullerton Sweet,	Sweet Bough.
Broadwell Sweet,		

TETOFSKY GROUP.

Summer apples, below medium in style, striped, of average quality. Valuable only in cold climate.

July,	Tetofsky.

TOMPKINS KING GROUP.

Early winter apples, large, attractively striped with red, variable but symmetrical in form, of superior quality and characteristic dense, coarse texture and aromatic yellowish flesh. Especially suited to the Western New York districts, but succeeding to a fair degree in all except the most northern districts.

Blenheim,	Hubbardston,	Ribston,
Fishkill,	Palouse,	Tompkins King.

TWENTY OUNCE GROUP.

Large, late fall, broadly splashed red apples, roundish in form, of good quality and with a coarse yellowish aromatic flesh. Grown more or less generally in all but the most northern districts.

Collamer,	Lyscom,	Twenty Ounce.

VANDEVERE GROUP.

Local in adaptation and confined mostly to the warmer parts of the State.

Ronk,	Vandevere.

WEALTHY GROUP.

Fruit undersized on old trees. Early and abundant croppers. Hardy and adapted to all of the apple districts of New York.

Peter,	Wealthy,

and several Minnesota seedlings.

WINESAP GROUP.

Winter apples, medium to large in size, dark red, rather solid and medium fine grain, of good but not high quality, quite good keepers. A group belonging to the South and West and of small importance in any of the apple districts of New York.

Arkansas,	Oliver,	Winesap,
Arkansas Black,	Paragon,	Winter Sweet Paradise.
Kinnaird,	Stayman Winesap,	

YELLOW BELLFLOWER GROUP

Medium to large apples, characteristically oblong conic, predominantly yellow, with a large somewhat remarkably open core. Flesh firm, crisp, aromatic and of high quality for culinary purposes. Somewhat general in distribution throughout the State but inclining to the southern and warmer districts.

Barry,	Moyer,	Summer Bellflower,
Flory,	Newman,	Titus Pippin,
Kirkland,	Occident,	Yellow Bellflower.
Mason Orange,	Ortley,	

YELLOW TRANSPARENT GROUP.

Early summer apples, of medium size and characteristically thin skin and tender flesh. Russian. Adapted to all New York districts.

Breskovka,	Thaler,	Yellow Transparent.
Red Transparent,		

FACTORS GOVERNING DISTRIBUTION.

A knowledge of the factors which govern the distribution of plants is essential to a clear understanding of the distribution of varieties. The natural factors (there are economic factors as well) which most largely determine the characters of the plants in any region are:— Latitude and altitude; temperature of air and soil; the water supply; the chemical and physical properties of the soil; and air currents. To these might be added insects and fungi which often help to determine the area of profit for a fruit or its varieties. But parasites are so largely dependent upon the other natural factors and upon the host plant that we need not consider them among the chief factors in distribution.

Latitude and altitude.— Latitude and altitude largely determine the annual temperature, amount and intensity of sunlight, and the length of the growing season. We shall find many sorts of apples, as those of the Ben Davis and Winesap groups, strongly influenced by latitude and altitude, quite aside from hardiness. So far as tree characters are concerned Ben Davis and Winesap are hardier than many varieties far better adapted to northern latitudes. It is an important fact that the metes and bounds of latitude are often set aside by local modifications. Thus there are, in all parts of New

York, valleys, large or small, protected from cold winds, open to sunshine, free from fogs, or comparatively free from frosts, which have advantages in these respects over other areas better situated as to latitude. In such favored localities adverse influences of latitude are offset and the list of desirable fruits is increased.

Temperature.— The chief factor in determining the distribution of fruits is temperature. Each fruit requires a certain amount of warmth for its development and can endure but a certain degree of cold. Investigations conducted by the Division of Biological Survey of the United States Department of Agriculture enabled them to lay down the following law* regarding temperature as a means of controlling the distribution of plants and animals. "*The northward distribution of terrestrial animals and plants is governed by the sum of the positive temperatures for the entire season of growth and reproduction, and the southward distribution is governed by the mean temperature of a brief period during the hottest part of the year.*" In fruit-growing it is found that the distribution of fruits and their varieties conforms to this law only in a broad and general way and yet sufficiently closely that we may make it a means, as accurate or more so than any other rule that has been laid down, of studying the relations of climate to the life events of plants and to the distribution of varieties.

The fruit-grower is chiefly concerned with the annual temperature and this is determined by latitude, altitude and proximity to large bodies of water. Variation in the surface of the country — hills and valleys — are often modifying agents of temperature and especially of spring and fall frosts. The warmth-retaining properties of the soil must often be taken into account. Beyond all question, the last named factor does not receive sufficient consideration and we shall often find that the adaptations of some varieties of fruits, especially of grapes and peaches and of some apples, which prefer warm soils, as sands and loams, depend largely upon the heat in the soil.

Water.—All plants are very sensitive about their supply of water and with a species which has been cultivated as long as the apple

*U. S. Dept. Agr., Biol. Surv. Bul. No. 10, p. 54.

it could not be otherwise than that some varieties would be endowed with constitutions better fitted for withstanding drought or an excess of water, than others. We must count moisture as one of the chief factors influencing the distribution of varieties. Not only must the rainfall be taken into account but the distribution throughout the year must be considered. The amount of water capable of being retained by a soil is of considerable importance. Strong dry or moist winds greatly influence the supply of water needed by plants; this is as true in winter as in summer, for moisture may be evaporated from the tree tops in winter by a dry or strong wind, or while the ground is frozen so that the normal supply is cut off from the roots, and winter-killing thus results. The Russian apples are well adapted to withstand the last named condition.

Soil.— The richness of the soil; its physical characters; its power to retain water; and its heating properties are all determinants of special adaptations of fruits to a region. But it is not sufficient to know that pears thrive on clay, peaches on sand, and apples on loamy soils. The varieties of these and of all other fruits have distinct preferences. Some varieties, as the Baldwin apple, Bartlett pear and Concord grape are cosmopolitan as to soils; but none of these, and no variety, is wholly indifferent to even slight variations. One of the most important matters before fruit-growers in the adaptabilities of fruits and their varieties to soil.

To some extent we can grow varieties upon soils which are uncongenial to them by grafting upon stocks better adapted to the soil in question.

Air currents.—Air currents are of minor importance compared with the other physical factors but are worthy of attention. Winds are beneficial when they bring warm air, when moisture laden, to keep frosty air in motion, and sometimes for the suppression of insects and fungi. They are detrimental when too dry, too strong, or too cold. Natural or artificial windbreaks may greatly modify the effects of air currents, though the value of the latter is usually over-estimated as their benefits are often offset by their bad effects.

FRUIT LISTS FOR THE SEVERAL POMOLOGICAL DISTRICTS OF NEW YORK.

A fruit list is an enumeration of the varieties which will thrive in a given region. All fruits when grown in different regions show variations in size, color, keeping quality and flavor of fruit; and in longevity, vigor and productiveness in the tree. Fruit lists take into consideration these variations. They show locations of dominance of the various varieties; classify varieties as to their likes and dislikes of soils; and indicate the susceptibilities to insect and fungus pests. The value of a fruit list is that it enables a fruit-grower to specialize more closely — to plant to better advantage. Such a list is to some extent an attempt to tell a man in advance what to plant.

A fruit list must not, however, be looked upon as infallible, or fixed. Far from it, for we shall never have sufficient knowledge to make a perfect list; new and better sorts will continue to appear; and lists will always be biased by the prejudices of the man or men making them. There is no certainty, either, that a list prepared for one region will be adapted to another in which the natural conditions seem to be the same.

For many years the American Pomological Society has issued a most serviceable catalogue of the fruits of North America north of Mexico. Fruit-growers regard this as the best authority for the territory covered as to the adaptability and value of the varieties of fruits to different sections. As stated in the last catalogue, "The entire territory is divided into nineteen pomological districts, with little regard to State or provincial boundaries, but with primary reference to the influence of latitude, elevation, prevailing winds, and oceanic and lacustrine exposures upon their adaption to pomological pursuits." This catalogue, while valuable, is too general. The nineteen large districts need to be subdivided if the catalogue is to become of much service to the fruit-grower in the selection of varieties for his own locality.

As a great horticultural State, and because of the diversity of its physical features, and by reason of the various atmospheric influences to which it is subject, New York is in need of a fruit catalogue to serve as a guide in the selection of varieties for the

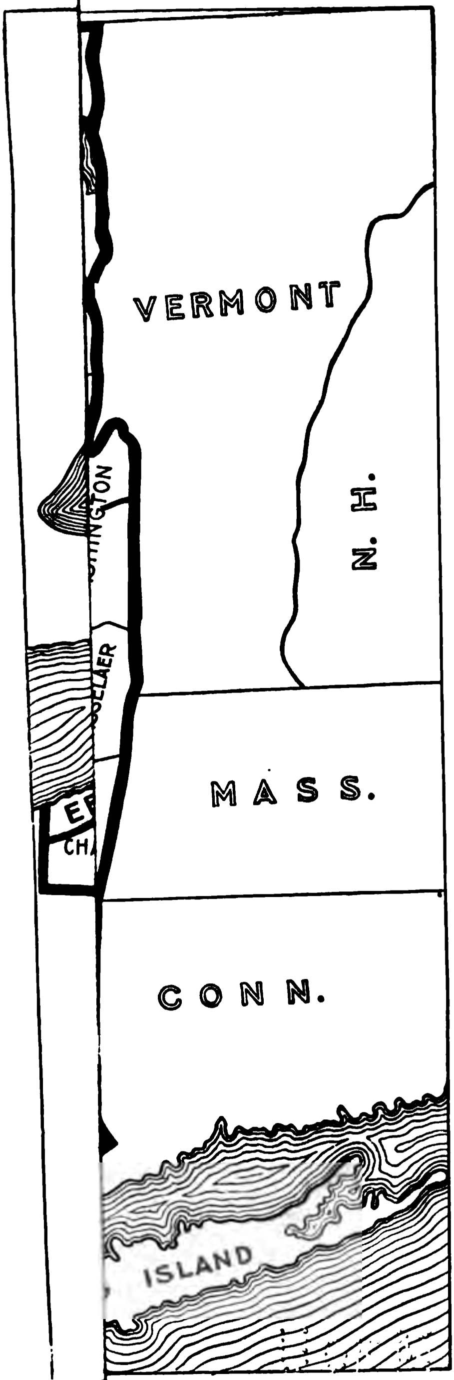
various physiographic divisions within her boundaries. The matter herewith presented is the beginning of such a catalogue and includes a preliminary list of apples for the various districts of the State.

The State of New York may be divided into nine primary pomological districts in accordance with the physical geography of the State but more particularly with reference to the distribution of its plants, both wild and domesticated. The chief authorities consulted in making such a division are Tarr's "The Physical Geography of New York State;" the New York Weather Bureau; the Weather Bureau of the U. S. Department of Agriculture; the Natural History of New York, Vol. 2, "Botany" by John Torrey; the horticultural literature of the State; and a subdivision of the State made by Beach in collecting information for "The Apples of New York."

In dividing the State into districts but little attention has been paid to the soils. The soils of New York, for most part, have been formed by glacial action and have been carried to and fro by the same agency, so that in no part of the State is there any great degree of uniformity in soil over a large area. Therefore, though recognizing that soil is important in determining areas of profitable fruit-growing, it has not been thought best to rely much on soil formation in laying out the pomological districts for the apple.

The following are the districts:

Long Island.— This district is composed of the sandy lowland of Long Island. It is formed by a low plain covered with a thick deposit of glacial drift in which sand predominates. The varieties of the fruit crops cultivated here, and especially of the apple, are not distinctive. The limits of the northern and of southern sorts seem to meet, giving a great number of varieties for the district and making it difficult to form a definite list.


VERMONT
N. H.
MASS.
CONN.
ISLAND

LIST OF VARIETIES FOR LONG ISLAND.

c, cider; d, dessert; k, kitchen.

WORTHY OF TRIAL.

HOME:
Akin—d
Ferdinand—d
Huntsman—d k
Milden—d k
Parry White—d
Victoria—d k

MARKET:
Arkansas—k
Black Ben Davis—k
Boiken—k
Eiser—k
Gano—k
Huntsman—d k
Hyde King—k
Olympia—d k
Palouse—d
Wabash Red—d

LOCAL MARKET:
Akin—d
Pease—d
Winter Banana—d k

RECOMMENDED.

HOME:
Autumn Bough—d k
Bullock—d
Cox Orange—d
Domine—d k
Early Harvest—d
Early Joe—d
Early Strawberry—d
English Russet—d c
Esopus *Spitzenburg*—d k
Fanny—d
Garden Royal—d
Golden Russet—d k c
Golden Sweet—d
Grimes—d k
Haskell—d
Hawley—d
Holland Pippin—k
Jefferis—d
Jersey Sweet—d
Keswick—k
Lady—d
Late Strawberry—d k
Longfield—d
Mother—d
Porter—d k
Primate—d
Summer Pearmain—d
Swaar—d
Titus Pippin—d k
Tolman *Sweet*—d k

CRABAPPLES:
Gibb—k
Marengo—d k
Red Siberian—k
September—d k
Transcendent—k
Whitney—d k
Yellow Siberian—k

MARKET:
Ben Davis—k
Cooper Market—k
English Russet d c
Esopus *Spitzenburg*—d k
(1) Golden Pippin—d k
Golden Russet—d k c
Gravenstein—d k
Grimes—d k
Lady Sweet—d k
Maiden Blush—k

WELL RECOMMENDED.

HOME:
Green and Yellow Newtown—d k
Jonathan—d k

MARKET:
Baldwin—d k
Fallawater—k
Green and Yellow Newtown—d k
Hubbardston—d k
Jonathan—d k

LOCAL MARKET:
Fall Pippin—d k
Sweet Bough—d k
Yellow Transparent—d k

LIST OF VARIETIES FOR LONG ISLAND — *Continued.*

c, cider; d, dessert; k, kitchen.

RECOMMENDED.

HOME:
Mann—k
Oldenburg—k
Pumpkin Sweet—k
Red Astrachan—d k
Rhode Island *Greening*—d k
Rome—k
Roxbury—d k
Stark—k
Sutton—d k
Sweet Winesap—d k
Tompkins King—d k
Twenty Ounce—k
Wagener—d k
Wealthy—d k
Westfield *Seek-No-Further*—d
York Imperial—d k

CRABAPPLES:
Excelsior—d k
Florence—k
Hyslop—k
Martha—d k

LOCAL MARKET:
Chenango—d
Jacobs Sweet—d
Lady—d
Lowell—d k
McLellan—d
Melon—d
Streaked Pippin—d k
Stump—d
Yellow Bellflower—k

Hudson Valley.— The region on both sides of the Hudson from Long Island to the Valley of Lake George in Warren and Washington counties. The varied topography and the several geological formations giving different soils, make it possible, and probably desirable, to subdivide this district into several secondary regions. But the district is considered as one in the horticultural literature of the State; our data have been collected for the united district; and since it would complicate the work of making out lists very greatly, subdivisions have not been made.

The complexities of climate, topography and soil, however, must be kept in mind in using the table of adaptations. Where the region touches the sea shore, and for several miles inland, the list

prepared for Long Island will be applicable. In the northern part of the region and the high altitudes, the varieties resommended for the Champlain Valley should receive consideration.

LIST OF VARIETIES FOR HUDSON VALLEY.

c, cider; d, dessert; k, kitchen.

WORTHY OF TRIAL.

HOME:
- Ferdinand—d
- Hoadley—k
- Louise—d
- Milden—d k
- Parry White—d
- Victoria—d k

MARKET:
- Bismarck—k
- Black Ben Davis—k
- Boiken—k
- Constantine—k
- Eiser—k
- Gano—k
- Grosh—k
- Hyde King—k
- Olympia—d k
- Palouse—d
- Wabash Red—d
- Wolf River—k

LOCAL MARKET:
- Pease—d
- Winter Banana—d k

RECOMMENDED.

HOME:
- Autumn Bough—d k
- Bullock—d
- Cox Orange—d
- Domine—d k
- Early Harvest—d
- Early Joe—d
- Early Strawberry—d
- English Russet—d c
- Fanny—d
- Garden Royal—d
- Golden Russet—d k c
- Golden Sweet—d
- Grimes—d k
- Haskell—d
- Hawley—d
- Holland Pippin—k
- Jefferis—d
- Jersey Sweet—d
- Keswick—k
- Lady—d
- Longfield—d
- Mother—d
- Pomme Grise—d
- Porter—d k
- Primate—d
- Summer Pearmain—d
- Swaar—d
- Titus Pippin—d k
- Tolman *Sweet*—d k
- Williams—d

CRABAPPLES:
- Gibb—k
- Marengo—d k
- Red Siberian—k
- September—d k
- Transcendent—k
- Whitney—d k
- Yellow Siberian—k

MARKET:
- Alexander—k
- Barringer—d
- Ben Davis—k
- Cooper Market—k
- English Russet—d c
- Fallawater—k
- (1) Golden Pippin—d k
- Golden Russet—d k c

WELL RECOMMENDED.

HOME:
- Esopus *Spitzenburg*—d k
- Green and Yellow Newtown—d k
- Jonathan—d k
- Late Strawberry—d

MARKET:
- Baldwin—d k
- Esopus *Spitzenburg*—d k
- Gravenstein—d k
- Green and Yellow Newtown—d k
- Hubbardston—d k
- Jonathan—d k
- Lady Sweet—d k
- Rhode Island *Greening*—d k
- Sutton—d k
- Sweet Winesap—d k
- Twenty Ounce—k

LOCAL MARKET:
- Fall Pippin—d k
- Sweet Bough—d k
- Yellow Transparent—d k

LIST OF VARIETIES FOR HUDSON VALLEY — *Continued.*

c, cider; d, dessert; k, kitchen.

RECOMMENDED.

MARKET—*Continued.*
Grimes—d k
McIntosh—d
Maiden Blush—k
Mann—k
Northern Spy—d k
Oldenburg—k
Pumpkin Sweet—k
Red Astrachan—d k
Red Canada—d k
Red Hook—k
Rock Pippin—k
Rome—k
Roxbury—d k
Stark—k
Tompkins King—d k
Wagener—d k
Wealthy—d k
Westfield *Seek-No-Further* —d
York Imperial—d k

CRABAPPLES:
Excelsior—d k
Florence—k
Hyslop—k
Martha—d k

LOCAL MARKET:
Chenango—d
Jacobs Sweet—d
Lady—d
Lowell—d k
McLellan—d
Melon—d
Streaked Pippin—d k
Stump—d
Yellow Bellflower—k

St. Lawrence and Champlain Valleys.— The high and rolling land tributary to Lake Champlain and the St. Lawrence river and such parts of the Adirondacks as are adapted to apple-growing. Three divisions could well be made of this district; the two valleys could be kept distinct, each to include only the area of lower land adjacent to the water; and the third to be the high uplands which run back into the Adirondacks. We have no data, however, which indicate that lists for the three districts would differ greatly and we have therefore included them as one. It is hardly necessary to say that only the hardiest varieties would thrive in the high uplands and that in favored locations near the water

some of the more southern and more tender sorts could be grown. In the regions near the lakes and the St. Lawrence the length of the growing season is one of the most important factors governing the suitability of varieties.

LIST OF VARIETIES FOR ST. LAWRENCE AND CHAMPLAIN VALLEYS.

c, cider; d, dessert; k, kitchen.

WORTHY OF TRIAL.

HOME:
- Adirondack—k
- Fall Harvey—d
- Gideon Sweet—d k
- Golden Sweet—d
- Hilaire—d
- Hoadley—k
- Louise—d
- Milden—d k
- Prolific Sweeting—d
- Rolfe—k
- Russian Baldwin—k
- Scarlet Pippin—d k
- Titovka—k
- Windsor—d

MARKET:
- Arctic—k
- Boiken—k
- Cranberry Pippin—k
- Dudley—k
- Eiser—k
- Fishkill—k
- Gideon Sweet—d k
- Hyde King—k
- Malinda—k
- Milwaukee—k
- Northwestern *Greening*—d k
- Oel Austin—d k
- Ontario—d k
- Patten—k
- Rutledge—k
- Starkey—d
- Wolf River—k

RECOMMENDED.

HOME:
- Blue Pearmain—d k
- Canada Baldwin—d
- Jewett *Red*—d
- Longfield—d
- Northern Sweet—d
- Pomme Grise—d
- St. Lawrence—d

CRABAPPLES:
- Gibb—k
- Marengo—d k
- Red Siberian—k
- September—d k
- Transcendent—k
- Whitney—d k
- Yellow Siberian—k

MARKET:
- Alexander—k
- Bismarck—k
- Constantine—k
- Gravenstein—d k
- Hibernal—k
- Pewaukee—k
- Red Astrachan—d k
- Red Canada—d k

CRABAPPLES:
- Excelsior—d k
- Florence—k
- Hyslop—k
- Martha—d k

LOCAL MARKET:
- Blue Pearmain—d k
- Canada Baldwin—d
- Jewett *Red*—d
- Yellow Transparent—d k

WELL RECOMMENDED.

HOME:
- Tolman *Sweet*—d k

MARKET:
- Baxter—k
- Fameuse—d
- McIntosh—d
- Oldenburg—k
- Scott—k
- Stone—d k
- Wealthy—d k

LOCAL MARKET:
- Bethel—d k

Mohawk Valley.— The valley of the Mohawk from Oneida Lake to the Valley of the Hudson. This district is one of indistinct boundaries and possibly should be divided into the Upper Mohawk and the Lower Mohawk districts in which case the Lower Mohawk could include the Schoharie Valley where some fruits succeed re-

markably well. A fruit list for the lower Mohawk would include some sorts recommended for the Hudson Valley. Hardiness is a prime requisite for the upper Mohawk, though since the season is somewhat longer some varieties can be grown which will not thrive in the district to the North.

LIST OF VARIETIES FOR MOHAWK VALLEY.

c, cider; d, dessert; k, kitchen.

WORTHY OF TRIAL.

HOME:
- Hilaire—d
- Hoadley—k
- Louise—d
- Milden—d k
- Rolfe—k
- Scarlet Pippin—d k
- Titovka—k
- Victoria—d k

MARKET:
- Arctic—k
- Bismarck—k
- Boiken—k
- Constantine—k
- Cranberry Pippin—k
- Dudley—k
- Eiser—k
- Fishkill—k
- Grosh—k
- Hyde King—k
- Olympia—d k
- Ontario—d k
- Starkey—d
- Sutton—d k
- Wolf River—k

LOCAL MARKET:
- Winter Banana—d k

RECOMMENDED.

HOME:
- Canada Baldwin—d
- Early Strawberry—d
- Golden Russet—d k c
- Golden Sweet—d
- Jewett *Red*—d
- Longfield—d
- Pomme Grise—d

CRABAPPLES:
- Gibb—k
- Marengo—d k
- Red Siberian—k
- September—d k
- Transcendent—k
- Whitney—d k
- Yellow Siberian—k

MARKET:
- Baldwin—d k
- Baxter—k
- Golden Russet—d k c
- Hubbardston—d k
- Kirkland—k
- Lady Sweet—d k
- Red Astrachan—d k
- Red Canada—d k
- Rhode Island *Greening*—d k
- Roxbury—d k
- Stone—d k
- Sweet Winesap—d k
- Westfield *Seek-No-Further*—d

CRABAPPLES:
- Excelsior—d k
- Florence—k
- Hyslop—k
- Martha—d k

LOCAL MARKET:
- Canada Baldwin—d
- Chenango—d
- Jewett *Red*—d
- Melon—d
- Stump—d
- Yellow Transparent—d k

WELL RECOMMENDED.

HOME:
- Esopus *Spitzenburg* (Schoharie Valley)—d k
- Tolman *Sweet*—d k

MARKET:
- Alexander—k
- Esopus *Spitzenburg* (Schoharie Valley)—d k
- Fameuse—d
- Gravenstein—d k
- McIntosh—d
- Northern Spy—d k
- Oldenburg—k
- Wealthy—d k

Eastern Plateau.— The Catskills and the high plateau to the west reaching to the basin of the Central Lakes. The western boundary of this region cannot be drawn with definiteness but the eastern boundary is well drawn being the highlands overlooking the Hudson Valley. Both the wild and the cultivated flora in this great region are variable in its different parts and in accordance with these differences, and to agree with the topography of the district, several subdivisions could be made. But it is an agricultural belt rather than a pomological one, though the apple succeeds remarkably well in some valleys, and apple growing is not sufficiently well developed to furnish data for reliable lists for all possible districts. The varieties named in the lists given are those which succeed well under many conditions and especially those of a somewhat adverse climate since so much of this district is mountainous or high and therefore cold.

LIST OF VARIETIES FOR EASTERN PLATEAU.

c, cider; d, dessert; k, kitchen.

WORTHY OF TRIAL.

HOME:
- Hilaire—d
- Hoadley—k
- Louise—d
- Milden—d k
- Rolfe—k
- Scarlet Pippin—d k
- Titovka—k
- Victoria—d k

MARKET:
- Alexander—k
- Bismarck—k
- Boiken—k
- Constantine—k

HOME:
- Eiser—k
- Fishkill—k
- Grosh—k
- Hyde King—k
- Olympia—d k
- Ontario—d k
- Palouse—d
- Starkey—d
- Sutton—d k
- Wabash Red—d
- Wolf River—k

LOCAL MARKET:
- Pease—d
- Winter Banana—d k

RECOMMENDED.

HOME:
- Autumn Bough—d k
- Early Strawberry—d
- Golden Russet—d k c
- Golden Sweet—d
- Haskell—d
- Hawley—d
- Jersey Sweet—d
- Jonathan—d k
- Longfield—d
- Pomme Grise—d
- Swaar—d
- Tolman *Sweet*—d k

CRABAPPLES:
- Gibb—k

HOME:
- Marengo—d k
- Red Siberian—k
- September—d k
- Transcendent—k
- Whitney—d k
- Yellow Siberian—k

MARKET:
- Golden Russet—d k c
- Gravenstein—d k
- Jonathan—d k
- Lady Sweet—d k
- Maiden Blush—k
- Mann—k

WELL RECOMMENDED.

HOME:
- Esopus *Spitzenburg*—d k

MARKET:
- Baldwin—d k
- Esopus *Spitzenburg*—d k
- Hubbardston—d k
- McIntosh—d
- Northern Spy—d k
- Rhode Island *Greening*—d k
- Sweet Winesap—d k

LIST OF VARIETIES FOR EASTERN PLATEAU — *Continued.*

c, cider; d, dessert; k, kitchen.

RECOMMENDED.

MARKET:
- Oldenburg—k
- Pumpkin Sweet—k
- Red Astrachan—d k
- Red Canada—d k
- Rome—k
- Roxbury—d k
- Stark—k
- Tompkins King—d k
- Wagener—d k
- Wealthy—d k
- Westfield *Seek-No-Further* —d

CRABAPPLES:
- Excelsior—d k
- Florence—k
- Hyslop—k
- Martha—d k

LOCAL MARKET:
- Chenango—d
- Jacobs Sweet—d
- Melon—d
- Stump—d
- Yellow Bellflower—k
- Yellow Transparent – d k

Central Lakes.— The great basin in which lie the Central, or Finger, Lakes, a region of very indefinite boundaries the fruit lands of which lie for most part in the lower and more level lands near the lakes. A glance at the accompanying list of apples will give an idea of the importance of this district in the apple industry. Unusually favorable conditions prevail in this and in the district to the north for the growth of the apple and especially favorable in the matter of climate. This and the following district comprise for most part what is known as the Western New York apple belt — far famed for the quality anl quantity of the product.

One of the chief assets of the Western New York apple belt, as has been indicated, is its climate. The climate as a whole is one of comparatively uniform temperatures and with well regulated conditions of humidity, both brought about by the large deep bodies of water in or adjoining the districts. A wide range of varieties is adapted to both districts, but nevertheless a few sorts, in a commercial way at least, have gained and maintain the lead.

LIST OF VARIETIES FOR CENTRAL LAKES.

c, cider; d, dessert; k, kitchen.

WORTHY OF TRIAL.

HOME:
- Akin—d
- Cox Orange—d
- Hoadley—k
- Louise—d
- Milden—d k
- Parry White—d
- Scarlet Pippin—d k
- Skank—d
- Victoria—d k

MARKET:
- Babbitt—k
- Bismarck—k
- Black Ben Davis—k
- Constantine—k
- Deacon Jones—k
- Eiser—k
- Gano—k
- Grosh—k
- Hyde King—k
- Kirkland—k
- Lee Sweet—k
- Olympia—d k
- Ontario—d k
- Palouse—d
- Wabash Red—d
- Wolf River—k

LOCAL MARKET:
- Akin—d
- Pease—d
- Winter Banana—d k

RECOMMENDED.

HOME:
- Autumn Bough—d k
- Early Harvest—d
- Early Joe—d
- Early Strawberry—d
- Esopus *Spitzenburg*—d k
- Fanny—d
- Garden Royal—d
- Genesee Flower—k
- Golden Russet—d k c
- Golden Sweet—d
- Haskell—d
- Hawley—d
- Jefferis—d
- Jersey Sweet—d
- Keswick—k
- Longfield—d
- Mother—d
- Pomme Grise—d
- Porter—d k
- Primate—d
- Seneca Favorite—d
- Summer Pearmain—d
- Swaar—d
- Tolman *Sweet*—d k

CRABAPPLES:
- Gibb—k
- Marengo—d k
- Red Siberian—k
- September—d k
- Transcendent—k
- Whitney—d k
- Yellow Siberian—k

MARKET:
- Ben Davis—k
- Esopus *Spitzenburg*—d k
- (1) Golden Pippin—d k
- Golden Russet—d k c
- Lady Sweet—d k
- Maiden Blush—k
- Mann—k
- Oldenburg—k
- Red Astrachan—d k
- Rome—k
- Stark—k
- Sutton—d k
- Wagener—d k
- Wealthy—d k
- Westfield *Seek-No-Further*—d

CRABAPPLES:
- Excelsior—d k
- Florence—k
- Hyslop—k
- Martha—d k

WELL RECOMMENDED.

HOME:
- Late Strawberry—d

MARKET:
- Alexander—k
- Baldwin—d k
- Boiken—k
- Gravenstein—d k
- Hubbardston—d k
- McIntosh—d
- Northern Spy—d k
- Pumpkin Sweet—k
- Red Canada—d k
- Roxbury—d k
- Sweet Winesap—d k
- Tompkins King—d k
- Twenty Ounce—k
- Rhode Island *Greening*—d k

LOCAL MARKET:
- Fall Pippin—d k
- Sweet Bough—d k

LIST OF VARIETIES FOR CENTRAL LAKES — *Continued.*

c, cider; d, dessert; k, kitchen.

RECOMMENDED.

LOCAL MARKET:
- Chenango—d
- Green Sweet—k
- Jacobs Sweet—d
- Lowell—d k
- McLellan—d
- Melon—d
- Stump—d
- Yellow Bellflower—k
- Yellow Transparent—d k

Ontario Shore.— The plain along the shore of Lake Ontario from the valley of the St. Lawrence to the Niagara River, extending from the Lake on the north a distance of several miles inland to an escarpment of limestone in the neighborhood of 600 feet in height. The plain is broken up by a series of parallel hills — the drumlins of the geologists. It differs from the preceding district chiefly in the matter of soils. Several distinct types of soils to be found in the Ontario Shore district seem to be well suited to the apple. For most part the soil is sandy or loamy, easily drained and worked. Soil and climatic conditions are such that trees are large, productive and long-lived and the fruit is of excellent quality. The list of varieties is largely the same as that recommended for the preceding district.

LIST OF VARIETIES FOR ONTARIO SHORE.

c, cider; d, dessert; k, kitchen.

WORTHY OF TRIAL.	RECOMMENDED.	WELL RECOMMENDED.
HOME:	HOME:	MARKET:
Brown Sweet—d k	Autumn Bough—d k	Alexander—k
Cox Orange—d	Early Harvest—d	Baldwin—d k
Hoadley—k	Early Joe—d	Grevenstein—d k
Louise—d	Early Starwberry—d	Hubbardston—d k
Milden—d k	Esopus *Spitzenburg*—d k	McIntosh—d
Parry White—d	Fanny—d	Northern Spy—d k
Scarlet Pippin—d k	Garden Royal—d	Oldenburg—k
Skank—d	Genesee Flower—k	Pumpkin Sweet—k
Victoria—d k	Golden Russet—d k c	Red Canada—d k
	Golden Sweet—d	Rhode Island *Greening*—d k
MARKET:	Haskell—d	Roxbury—d k
Babbitt—k	Hawley—d	Sweet Winesap—d k
Bismarck—k	Jefferis—d	Tompkins King—d k
Black Ben Davis—k	Jersey Sweet—d	Twenty Ounce—k
Constantine—k	Keswick—k	Wealthy—d k
Deacon Jones—k	Late Strawberry—d	

List of Varieties for Ontario Shore — *Continued.*

c, cider; d, dessert; k, kitchen.

WORTHY OF TRIAL.

Market:
- Eiser—k
- Gano—k
- Grosh—k
- Hyde King—k
- Lee Sweet—k
- Olympia—d k
- Ontario—d k
- Palouse—d
- Wabash Red—d
- Wolf River—k

Local Market:
- Pease—d
- Winter Banana—d k

RECOMMENDED.

Home:
- Longfield—d
- Mother—d
- Pomme Grise—d
- Porter—d k
- Primate—d
- Summer Pearmain—d
- Swaar—d
- Tolman *Sweet*—d k

crabapples:
- Gibb—k
- Marengo—d k
- Red Siberian—k
- September—d k
- Transcendent—k
- Whitney—d k
- Yellow Siberian—k

Market:
- Ben Davis—k
- Boiken—k
- Cooper Market—k
- Esopus *Spitzenburg*—d k
- (1) Golden Pippin—d k
- Golden Russet—d k c
- Lady Sweet—d k
- Maiden Blush—k
- Mann—k
- Red Astrachan—d k
- Rome—k
- Stark—k
- Sutton—d k
- Wagener—d k
- Westfield *Seek-No-Further* —d

crabapples:
- Excelsior—d k
- Florence—k
- Hyslop—k
- Martha—d k

Local Market:
- Chenango—d
- Green Sweet—k
- Jacobs Sweet—d
- Lowell—d k
- McLellan—d
- Melon—d
- Stump—d
- Yellow Bellflower—k
- Yellow Transparent d k

WELL RECOMMENDED.

Local Market:
- Fall Pippin—d k
- Sweet Bough—d k

Erie Shore.— The plain along the shore of Lake Erie from the Niagara River to the western boundary of the State, a very narrow

strip of land bounded on the south by a high escarpment and gradually descending beneath the lake level on the north. This district is largely given up to grape growing and it has been exceedingly difficult to secure sufficient data from which to form a list of apples.

LIST OF VARIETIES FOR ERIE SHORE.

c, cider; d, dessert; k, kitchen.

WORTHY OF TRIAL.

HOME:
- Cox Orange—d
- Hoadley—k
- Louise—d
- Milden—d k
- Parry White—d
- Victoria—d k

MARKET:
- Babbitt—k
- Bismarck—k
- Boiken—k
- Constantine—k
- Deacon Jones—k
- Eiser—k
- Grosh—k
- Hyde King—k
- Olympia—d k
- Palouse—d

HOME:
- Wabash Red—d
- Wolf River—k

LOCAL MARKET:
- Pease—d
- Winter Banana—d k

RECOMMENDED.

HOME:
- Autumn Bough—d k
- Early Harvest—d
- Early Joe—d
- Early Strawberry—d
- Esopus *Spitzenburg*—d k
- Fanny—d
- Garden Royal—d
- Golden Russet—d k c
- Golden Sweet—d
- Haskell—d
- Hawley—d
- Jefferis—d
- Jersey Sweet—d
- Keswick—k
- Late Strawberry—d
- Mother—d
- Pomme Grise—d
- Porter— d k
- Primate—d
- Summer Pearmain—d
- Tolman *Sweet*—d k

CRABAPPLES:
- Gibb—k
- Marengo—d k
- Red Siberian—k
- September—d k
- Transcendent—k
- Whitney—d k
- Yellow Siberian—k

MARKET:
- Alexander—k
- Epsopus *Spitzenburg*—d k
- (I) Golden Pippin—d k
- Golden Russet—d k c
- Gravenstein—d k
- Lady Sweet—d k
- Maiden Blush—k
- Northern Spy—d k
- Red Astrachan—d k
- Red Canada—d k
- Rome—k
- Stark—k
- Sutton—d k
- Sweet Winesap—d k
- Tompkins King—d k

WELL RECOMMENDED.

MARKET:
- Baldwin—d k
- Hubbardston—d k
- McIntosh—d
- Oldenburg—k
- Pumpkin Sweet—k
- Rhode Island *Greening* —d k
- Roxbury—d k
- Wealthy—d k

LOCAL MARKET:
- Fall Pippin—d k
- Sweet Bough—d k

LIST OF VARIETIES FOR ERIE SHORE — *Continued.*

c, cider; d, dessert; k, kitchen.

RECOMMENDED.

MARKET:
- Twenty Ounce—k
- Wagener—d k
- Westfield *Seek-No-Further*—d

CRABAPPLES:
- Excelsior—d k
- Florence—k
- Hyslop—k
- Martha—d k

LOCAL MARKET:
- Chenango—d
- Jacobs Sweet—d
- Lowell—d k
- McLellan—d
- Melon—d
- Stump—d
- Yellow Bellflower—k
- Yellow Transparent—d k

Western Plateau.— The high plateau to the south of the Ontario and Erie Shores and west of the Central Lakes. This, like the Eastern Plateau, is a region of indefinite boundaries, varied topography, and relatively of smaller importance in the apple industry than the neighboring districts. Here again it has been difficult to get sufficient data upon which to base a list and it has been necessary to resort to some extent to making comparisons as to the behavior of varieties in other districts where conditions seem to be much the same.

LIST OF VARIETIES FOR WESTERN PLATEAU.

c, cider; d. dessert; k, kitchen.

WORTHY OF TRIAL.

HOME:
- Cox Orange—d
- Hoadley—k
- Louise—d
- Milden—d k
- Parry White—d
- Victoria—d k

MARKET:
- Alexander—k
- Babbitt—k
- Bismarck—k
- Boiken—k
- Constantine—k
- Eiser—k

RECOMMENDED.

HOME:
- Early Harvest—d
- Early Joe—d
- Early Strawberry—d
- Esopus *Spitzenburg*—d k
- Fanny—d
- Garden Royal—d
- Genesee Flower—k
- Golden Russet—d k c
- Haskell—d
- Hawley—d
- Jefferis—d
- Jersey Sweet—d
- Keswick—k
- Late Strawberry—d

WELL RECOMMENDED.

MARKET:
- Baldwin—d k
- Hubbardston—d k
- Rhode Island *Greening*—d k
- Roxbury—d k
- Tompkins King—d k
- Sweet Winesap—d k

LOCAL MARKET:
- Fall Pippin—d k

LIST OF VARIETIES FOR WESTERN PLATEAU — *Continued.*

c, cider; d. dessert; k, kitchen.

WORTHY OF TRIAL.

MARKET:
- Grosh—k
- Hyde King—k
- Lee Sweet—k
- Olympia—d k
- Palouse—d
- Sutton—d k
- Wabash Red—d
- Wolf River—k

LOCAL MARKET:
- Pease—d
- Winter Banana—d k

RECOMMENDED.

HOME:
- Mother—d
- Pomme Grise—d
- Porter—d k
- Primate—d
- Summer Pearmain—d
- Tolman *Sweet*—d k

CRABAPPLES:
- Gibb—k
- Marengo—d k
- Red Siberian—k
- September—d k
- Transcendent—k
- Whitney—d k
- Yellow Siberian—k

MARKET:
- Esopus *Spitzenburg*—d k
- (1) Golden Pippin—d k
- Golden Russet—d k c
- Gravenstein—d k
- Lady Sweet—d k
- McIntosh—d
- Maiden Blush—k
- Mann—k
- Northern Spy—d k
- Oldenburg—k
- Pumpkin Sweet—k
- Red Astrachan—d k
- Red Canada—d k
- Rome—k
- Stark—k
- Twenty Ounce—k
- Wagener—d k
- Wealthy—d k
- Westfield *Seek-No-Further* —d

CRABAPPLES:
- Excelsior—d k
- Florence—k
- Hyslop—k
- Martha—d k

LOCAL MARKET:
- Chenango—d
- Lowell—d k
- McLellan—d
- Melon—d
- Stump—d
- Sweet Bough—d k
- Yellow Bellflower—k
- Yellow Transparent—d k

VARIETIES DISCARDED AS UNWORTHY A PLACE IN "THE APPLES OF NEW YORK."

A catalogue of the apples of New York is not complete without a list of varieties discarded as unworthy of consideration. Such a list becomes a historical record which may serve to prevent the wider distribution of the black-listed sorts, the multiplication of synonyms, the reintroduction of the worthless sorts at some future time, and to serve in the comparative study of the apple. The varieties listed are those which are grown either on the Station grounds or in some part of the State and therefore were eligible to discussion in "The Apples of New York;" the list is not a systematic collection of unworthy sorts for the whole country.

VARIETIES DISCARDED.

Ananarnoe,
Bancroft,
Blood Red (crab),
Champaign,
Charlock Reinette,
Crimean,
Daddy,
Dickens Sweet,
Early Melon,
Glass Green,
Golden Winter Pearmain (of Hogg),
July Cluster,
Late Duchess,
Letitz,
Manwaring,
Mellott,
Melonen,
Mzensk Sweet,
Old Century,
Persian Bogdanoff,
Rebel,
Sankermanky,
Sigfried,
Smelling,
Striped Winter,
Summer Red Calville,
Sweet Romanite,
Vochin Crimean,
Voronesh Rosy,
White Doctor,
William Prince.

VARIETIES NOT SUFFICIENTLY TESTED TO FIND A PLACE IN "THE APPLES OF NEW YORK."

To complete the survey of contemporary varieties, it is worth while adding a list of the sorts now on the Station grounds which have not been sufficiently tested to warrant publication of their qualities. This list neither recommends nor condemns the varieties mentioned. The names published are those under which the trees have been received and until tested further the Station cannot vouch for their correctness.

APPLES NOT FULLY TESTED.

Alabama,
Alegerienne,
Alice,
American Best,
American Codling,
Anis Rose,
Armorel,
Ashton,
Avery,
Axident,
Barnes Choice,
Barton,
Battyana,
Bayard,
Beauty of Bath,
Berkoff,
Bloomfield,
Blushing Bride,
Bostick Queen,
Brackett,
Bramley,
Brown,
Buda Summer,
Calville de Oullins,
Centennial,
Challenger,
Cheshunt,
Chester,
Cleopatra,
Colonial Pippin,
Counseilor Niemetz,
Cross,
Daru,
De Chataignier,
Delicious,
D' Eve,
Dickey,
Dixon,
Dona Maria,
Draper Best,
Eicke,
Ensee,
Eper,
Fillepasable,
Frosakers,
Gascoyne,
Gem,
Gerard,
Gimmersta,
Golden Noble,
Golden Nonpareil,
Golden Pearmain,
Gold Ridge,
Gracie,
Graf Luxbury,
Grand Duke Michels Pearmain,
Halt,
Hanlon Sweet,
Headlight,
Hedrick,
Henry Clay Summer,
Hohenheimer,
Houghton,
Houghton Sweet,
Huntereon,
Hurne,
Ieanne Hardy,
Jersey Blue,
Johnsonite,
Jones,
Keskemet,
King David,
King of Pippins,
Lady Sudeley,
Lancaster,
Large Yellow Pippin,
Legal Tender,
Lombard,
Longevity,
Longkeeper,
Lord,
Luckey,
McCrosky,
Magnolia,
Magyar,
Mexico,
Mihalyfi,
Mock,

APPLES NOT FULLY TESTED — *Concluded.*

Mon Desire,
Moore Extra,
Morse,
Munroe Favorite,
Nichner Strawberry,
Noble Sovar,
Norton Red,
Nyari Piros,
Nyari Vaj.
Oak,
Oberly Late Keeper,
Old Garden,
Olga,
Oramie,
Oszi Vaj.,
Ozone,
Paul Long,
Peach Blow,
Perry,
Pioneer,
Prince Double,
Prince Rudolph,
Prince Rudolph Imperial,
Princess Fossia,
Princess Wilhelma von Preussen,
Purity,
Queen of the West,
Red Carver,
Reders Gold Reinette,
Red Paradise,
Red Queen,
Red Statiner,
Regmalard,
Richard Early Winter,
Ringstads,
Rioter,
Rittenhouse,
Robert,
Robine,
Royal Snow,
Ruby Gem,
Rutherford,
Sandbrook,
Sekula,
Shannon Improved,
Shepherd Perfection,
Shull,
Skelton,
Skruishappel,
Snyder
Spasovka,
Springdale,
Staringe,
Stenkyrke,
Sterns,
Striped July,
Sulphur,
Summer Wafer,
Superb Sweet,
Svensk Vinter Postof,
Sweet Jonathan,
Sweet Longfield,
Terdika,
T. H. Gold Reinette,
Transparent de Cronals,
Tukor,
Two Faced,
Ulysses,
Upp,
Vancouver,
Vandevere Improved,
Ver,
Virginia Beauty,
Voronesh Red Summer,
Wagener Improved.
Wakeman,
Whinnery,
Wiener,
Winter Citron,
Winterstein,
York Stripe,
Zoar,
Zolotoreff,
Zuzoff Winter.

CATALOGUE OF APPLES.

ABBREVIATIONS AND MARKINGS.

Size.— l, large; m, medium; s, small; v, very.

Form.— a, angular; c, conical; i, irregular; o, oblate; ob, oblong; ov, ovate; r, roundish.

Color.— b, blush; c, carmine; d, dark; g, green; l, light; r, red; ru, russet; s, striped; w, white; y, yellow.

Flavor.— a, acid; b, brisk; m, mild; s, sweet; sa, subacid.

Quality.— b, best; g, good; f, fair; p, poor; v, very.

Use.— c, cider; d, dessert; k, kitchen.

Market.— h, home; e, export; lm, local market; m, market.

Season.— The abbreviations of the months.

Starring.— *, recommended; **, well recommended; +, worthy of trial; —, undesirable; blank, not reported on.

NOTE: Varieties in the following table, as well as in the preceding lists, that are "well recommended" for market are also usually well adapted for home use.

No.	VARIETY.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
1	Adirondack	m	r c	y r s	m sa	g	Oct., Jan.	k	h	N. Y.
2	Admirable	m	r o c	g y	m sa	g—vg	Oct., Jan.	d	h	Eng.
3	Akin	m	r o i	y r s	b sa	g	Jan., June	d	h lm	Ill.
4	Albion	l—vl	r ob	y g	m sa	g	Oct., Jan.	d k	h	Unk.
5	Alexander	vl	r o c	y r s	m sa	f—g	Sept., Nov.	k	m	Rus.
6	(II) Allington	m—l	r i	g y r s c	b sa	g	Nov., Jan.	d k	h	Eng.
7	Allison	m	o a	g r s	m sa	f	Mar., May	k	m	Tenn.
8	Amassia	m	r c	y g r s	m sa	g—vg	Dec., Apr.	d	h	Eu.
9	American Blush									
10	American Pippin	m	o	g r s	m sa	p—g	May	k c	h	Unk.
11	Amos	m—s	r o	y b	b sa	f—g	Nov., Mar.			Unk.
12	Amsterdam	m	r o	g y r s	s	g	Oct., Nov.	d	h	N. Y.
13	Andrews	s	r c	y g r s	m sa	f—g	Mar., June	d	h	Unk.
14	Anisim	m—s	r c	g y r	m sa	g	Oct., Dec.	d	h	Rus.
15	Antonovka	l	r	y	b sa	g	Oct.	k	h	Rus.
16	Aport Orient	l	r ob c	y r s	m sa	f	Aug.	k	h	Rus.
17	Arctic	l—m	r o c	y r s	m sa	g	Oct., Feb.	k	m	N. Y.
18	Arkansas	l—m	r c	g y r s	sa	g	Dec., May	k	m	Ark.
19	Arkansas Beauty	m—l	r c	g y r s	m sa	g	Jan., Feb.	k	m	Ark.
20	Arkansas Black	m	r	y d r	b sa	g—vg	Dec., Apr.	k	m	Ark.
21	Arnold	m	o	y w b	m sa	vg	Nov., Mar.	d	h	Can.
22	Arthur	m—s	ob	y g r s	sa	f—g	Oct., Jan.	k	h	Ia.
23	Aucuba	m	r c	y r s	b sa	g—vg	Oct., Jan.	k	h	Fr.
24	August	m—s	r o c	g y r s	m sa	f	Aug., Sept.	k	h	Minn.
25	Augustine	—l	r ob c	y r s	s	g	Aug.	d	h	Unk.
26	Autumn Bough	l	ob c	y	s	vg	Aug., Sept.	d k	h	Am.
27	Autumn Streaked	l	r o	y r s	sa	g	Sept.	k	h	Rus.
28	Autumn Swaar	m—l	r o c	g y	m sa	vg	Sept.	b k	h	Unk.
29	Autumn Sweet Swaar	l	r o	y	vs	vg—b	Sept., Oct.	d	h	Unk.
30	Babbitt	l	r o	y r s	b sa	g—vg	Nov., Feb.	k	m	Ill.
31	Bailey Spice	m	r c	y	sa	g—vg	Sept., Oct.	d	h	N. Y.
32	Bailey *Sweet*	l—m	r c	y r s	s	vg	Oct., Jan.	d k	h	N. Y.?
33	Baker	m—l	r c	y g r s	m sa	g	Oct., Feb.	k	m	Conn.
34	Baker Sweet	m	r	y	s	g—vg	Nov., Dec.	d	h	Conn.
35	Baldwin	l	r c	y r s	b sa	g—vg	Nov., Mar.	d k	m	Mass.
36	Banana Sweet	l	r c	g y b	s	g	Jan., Mar.	d k	h	N. J.
37	Banks	A bud sport of Gravenstein, much higher colored than that variety.								
38	Baptist	m—s	o r	g y r s	m sa	f—g	Jan., June	d	h	Ky.
39	Barbel	m—l	o c	y r	sa	g	Oct., Feb.	d	h	Rus.
40	Barringer	l—m	r c	r s	m sa	vg	Dec., Mar.	d	m	N. Y.
41	Barry	m—l	r o	y b	b sa	g	Feb., June	k	m	N. Y.
42	Batullen	m	r c	y b	sa	vg	Nov., Mar.	d	h	Eu.
43	Baxter	l—vl	r c	y r s	m sa	f—g	Nov., Jan.	k	m	Can.
44	Beach	m	r	y r s	sa	f—g	Feb., May	k	m	Ark.
45	Beautiful Arcad	m	ob	y r s	s	vg	Aug., Sept.	d	h	Rus.
46	Beauty of Kent	l	r	g y r s	sa	g	Oct., Nov.	k	h	Eng.
47	Belborodooskoe	m—l	r	g y	m sa	g	Aug.	k	h	Rus.
48	Belle et Bonne	l—vl	r o	y g	m sa	g	Nov., Jan.	k	m	Eu.
49	Belmont	m—l	r ob c	y b	m sa	vg	Oct., Feb.	k d	h lm	Pa.
50	Ben Davis	m—l	r ob c	y r s	m sa	g	Jan., June	k	m	Ky.?
51	Benninger	m	r o	y r s	m sa	g	Aug., Sept.	d	h	Pa.
52	Benoni	m	r c	y r s	sa	g—vg	Aug., Sept.	d	h	Mass.

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastern Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	REMARKS.
1			+							Promising early winter apple for Northern New York.
2	—	—	—	—	—	—	—	—	—	Not recommended for cultivation in New York.
3	+		—	—		+				A newly introduced beautiful apple of good quality. Worthy of testing.
4	—	—	—	—	—	—	—	—	—	Surpassed by others of its season.
5	—	*	*	**	+	**	**	*	+	Tree characters good. Fruit large and beautiful but of only fair quality. Promising commercially.
6										An English variety not tested in New York.
7										A Southern apple which does not appear promising in New York.
8										An European variety of doubtful value for New York.
9										Locally applied to Hubbardston.
10	—	—	—	—	—	—	—	—	—	Probably two varieties under this name.
11	—	—	—	—	—	—	—	—	—	A Southern variety worthless in New York.
12	—	—	—	—	—	—	—	—	—	Not known outside of locality in which it originated.
13	—	—	—	—	—	—	—	—	—	Worthless in New York.
14	—	—	—	—	—	—	—	—	—	May be of value where superior hardiness is a prime requisite.
15	—	—	—	—	—	—	—	—	—	Of no value for New York.
16	—	—	—	—	—	—	—	—	—	Not recommended for New York.
17			+	+						Worthy of trial in Northern New York.
18	+	—	—	—	—	—	—	—	—	Valuable in the South but not in New York unless it be in Long Island.
19	—	—	—	—	—	—	—	—	—	Not valuable.
20	—	—	—	—	—	—	—	—	—	Not valuable in New York unless it be in Long Island.
21										A Northern Spy seedling. Too tender for market. May be valuable for home use.
22	—	—	—	—	—	—	—	—	—	A Northwestern variety nearly as hardy as Oldenburg.
23										A French apple of doubtful value here.
24	—	—	—	—	—	—	—	—	—	Not recommended for New York.
25	—	—	—	—	—	—	—	—	—	Now unknown in New York.
26	*	*			*	*	*	*		Tree characters good. Ranks among our best sweet apples for home use.
27	—	—	—	—	—	—	—	—	—	Somewhat like the Oldenburg but surpassed by that variety.
28	—	—	—	—	—	—	—	—	—	Hardy and vigorous but lacks productiveness. Now seldom planted.
29	—	—	—	—	—	—	—	—	—	Crowded out by better sorts of its season.
30	—	—	—	—	—	+	+	+	+	Although a shy bearer in Eastern New York, promising in western part of State.
31	—	—	—	—	—	—	—	—	—	Now nearly obsolete in New York.
32	—	—	—	—	—	—	—	—	—	An old variety. Fruit of fine appearance. Tree characters undesirable.
33	—	—	—	—	—	—	—	—	—	An old variety superceded by the Baldwin. Nearly obsolete.
34	—	—	—	—	—	—	—	—	—	An old variety, productive. No commercial importance.
35	**	**	—	*	**	**	**	**	**	Standard winter apple of New York.
36										Little known in New York.
37										
38	—	—	—	—	—	—	—	—	—	Fruit very inferior.
39	—	—	—	—	—	—	—	—	—	A hardy tree bearing rather inferior fruit.
40		*								A promising apple long known in Columbia County.
41										A recent introduction not well tested.
42										Unproductive at this station.
43	—	—	**	*	—	—	—	—	—	Valuable in Northern New York. Blue Pearmain type.
44	—	—	—	—	—	—	—	—	—	New. Not promising in this State.
45	—	—	—	—	—	—	—	—	—	Not recommended for New York.
46										It is but little known in New York.
47	—	—	—	—	—	—	—	—	—	Not worthy of attention in this State.
48	—	—	—	—	—	—	—	—	—	An old variety not equal to standard kinds.
49	—	—	—	—	—	—	—	—	—	Valuable for home orchards only. Tree susceptible to disease. Fruit does not ship well.
50	*	*	—	—	—	*	*	—	—	Trees hardy, healthy, vigorous, productive. Lacking in quality.
51										A pleasant flavored dessert apple. Not well tested in N. Y.
52	—	—	—	—	—	—	—	—	—	A fine dessert apple, attractive, excellent quality. Not large enough for market.

No.	VARIETY.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
53	Bentley..........	m	r o bc	y r s	s	g	Dec., May.	k	h	Va.?
54	Bergen..........	m	r	g w r s	m sa	g	Jan., Feb.	k d	h	N. Y.
55	Bess Pool........	m	r c	y r s	b sa	g	Nov., Mar.	d k	h	Eng.
56	Bethel...........	l	r c	y r s	m sa	f—g	Nov., Mar.	k d	lm	Vt.
57	Bethlehemite.....	m	r o c	y g r s	m sa	g—vg	Nov., Mar.	d k	h	O.?
58	Bietigheimer.....	vl	r o c	y r s	sa	f—g	Sept., Oct.	k	m	Ger.
59	Billy Bond.......	l—m	r ob c	y r s	sa	g	Oct., Jan.	k	m	N. Y.
60	Birth............	m—l	r c	g y bl	m sa	f	Sept.	k	h	Rus.
61	Bismarck.........	l—vl	r o c	y r s	sa	f—g	Oct., Dec.	k	m	N. Z.
62	Black Annette....	m—s	r	r	m sa	g	Nov., Dec.	d	h	Unk.
63	Black Annette....	m	r o	g d r s	m sa	vg	Dec., Apr.	d	h	Unk.
64	Black Ben Davis .	m—l	r c	y d r	m sa	g	Jan., Apr.	k	m	Ark.
65	Black Gilliflower..	m—l	o b c	y g d r	m sa	g	Oct., Feb.	d	h m	Am.
66	Black *Jersey*.....	m	r	y d r s	m sa	f—g	Nov., Feb.	d	h	Unk.
67	Blenheim.........	l—m	r o c	y r	m sa	g—vg	Oct., Dec.	d k	h	Eng.
68	Blue Pearmain...	l—m	r	y d r s	m sa	g	Oct., Mar.	d k	h lm	Unk.
69	Blushed Calville..	m—l	r c	y g	sa	f—g	Aug.	k	h	Rus.
70	Bogdanoff Glass..	l	r c	g y b	b sa	f—g	Nov., Feb.	k	lm	Rus.
71	Boiken...........	m—vl	o	y b	b sa	g	Nov., Mar.	k	m	Eu.
72	Bonum...........	m—l	o	y r s	m sa	vg	Sept., Nov.	d	h	N. C.
73	Borovinka.......	m—l	r	y r s	sa	g	Aug., Sept.	k	h	Rus.
74	Borsdorf.........	m—s	o	y b	m sa	f	Nov., Feb.	k	h	Ger.
75	Boskoop.........	l	o	y g r	b sa	g	Sept., Nov.	k	m	Eu.
76	Boston Russet....	m	r c	y g ru	m sa	f—g	Jan., Apr.	k	h	N. Y.
77	Bottle Greening ..	m—l	r o c	g y b	sa	g—vg	Oct., Mar.	d k	h lm	Vt.?
78	Boy's Delight....	m	r	g y r s	m sa	g	Oct., Jan.	d	h	Can.
79	Breskovka.......	m	r	y	sa	f—g	Aug., Sept.	k	h	Rus.
80	Brownlees.......	m—l	o	y ru	b sa	vg	Oct., Jan.	d k	h	Eng.
81	Brown Sweet.....	l	ob c	g y b	s	g—vg	Sept., Jan.	d k	h	N. Y.
82	Buckingham.....	l	o	y g r s	m sa	f—g	Nov., Apr.	k	m	Am.
83	Bullock..........	m	r c	y g ru	m sa	vg—b	Oct., Jan.	d	h	N. J.
84	Bunker Hill......	m	r c	y r s	sa	vg	Oct.	d	h	N. Y.
85	Butter...........	m	r	y	s	g—vg	Sept., Oct.	k	h	Pa.
86	Cabashea........	l—vl	r o	y g r s	b sa	g	Sept., Oct.	k d	h	N. Y.
87	Campfield........	m—l	r o	y r s	s	g	Dec., May	c k	h	N. J.
88	Canada Baldwin..	m	r o c	y g r s	m sa	g—vg	Nov., Jan.	d	h lm	Can.
89	Canada Reinette..	m—l	r o c	y b	sa	vg	Dec., Apr.	d k	m	Unk.
90	Cannon *Pearmain*.	m—l	r ov	g y r s	sa	g	Jan., Apr.	k	m	Am.
91	Carlough.........	m—l	r c	g y b	m sa	g	Nov., Apr.	d k	h lm	N. Y.
92	Carpentin........	s—vs	r c	r ru	b sa	vg	Dec., Apr.	d	h	Unk.
93	Cathead.........	vl	r	g	sa	g	Oct., Nov.	k	h	Eu.
94	Caywood........	m	o	y b	m sa	g	Jan., Apr.	d	h	N. Y.
95	Celestia..........	m—l	r c	g y bl	m sa	g	Oct., Jan.	d	h	O.
96	Champlain.......	m—l	r c	g y	b sa	g—vg	Aug., Oct.	k d	h	Unk.
97	Chandler.........	l	r o	g y r s	sa	g—vg	Oct., Dec.	d	h	Am.
98	Charlamoff.......	l—m	r ob	y r s	sa	g	Aug.	k	h	Rus.
99	Cheeseboro......	l—vl	r c	g ru	m sa	f	Oct., Dec.	k	h	Unk.
100	Chenango........	l—m	r ob c	y r s	m sa	g—vg	Aug., Sept.	d	lm	N. Y.?
101	Clapper Flat.....	m	o c	y r s	sa	g	Sept., Oct.	k	h	N. Y.
102	Clarke...........	m—l	r o c	g y b l	b sa	g—vg	Oct., Jan.	d	h	N. Y.
103	Clayton..........	l—m	r o c	y r s	m sa	g	Jan., May	k d	m	Ind.
104	Clyde............	l	r ob c	g y r s	sa	g—vg	Oct., Dec.	d k	m	N. Y.
105	Coffelt...........	m	r o	y r s	m sa	g	Jan., May	k	m	Ark.

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastern Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	REMARKS.
53	—	—	—	—	—	—	—	—	—	Tree characters good. Fruit inferior in size and quality. Not valuable.
54	—	—	—	—	—	—	—	—	—	A local variety of no importance.
55	—	—	—	—	—	—	—	—	—	An English variety. Poor cropper in New York.
56	—	—	**	—	—	—	—	—	—	Blue Pearmain type. Valuable in Northeastern New York.
57	—	—	—	—	—	—	—	—	—	Newtown Spitzenburg type but surpassed by that variety.
58	—	—	—	—	—	—	—	—	—	Fit for exhibition purposes only.
59	—	—	—	—	—	—	—	—	—	Tree characters good. Fruit inferior in quality. Of questionable value.
60	—	—	—	—	—	—	—	—	—	Of no value in this State.
61	—	+	*	+	+	+	+	+	+	Tree healthy, hardy, bears young and productive. Fruit attractive but inferior in quality.
62	—	—	—	—	—	—	—	—	—	Now obsolete in New York. Distinct from next.
63										Has proved very hardy in the Northwest.
64	+	+				+	+			Ben Davis type, and probably of some value.
65	—	—	—	—	—	—	—	—	—	An old variety, valuable only for home use.
66	—	—	—	—	—	—	—	—	—	An old variety now practically obsolete.
67	—	—	—	—	—	—	—	—	—	Fruit is desirable but tree characters are unsatisfactory.
68	—	—	*	—	—	—	—	—	—	An old hardy variety now rarely planted in New York.
69	—	—	—	—	—	—	—	—	—	Of no value in this State.
70	—	—	—	—	—	—	—	—	—	Hardy. May have some value in northern portions of apple belt.
71	+	+	+	+	+	**	*	+	+	Newly introduced and promising in some districts.
72	—	—	—	—	—	—	—	—	—	Not adapted to this latitude.
73	—	—	—	—	—	—	—	—	—	Resembles Oldenburg and surpassed by it.
74	—	—	—	—	—	—	—	—	—	Not recommended for planting in New York.
75										Tree qualities good. Quality inferior. Perhaps worthy of testing.
76	—	—	—	—	—	—	—	—	—	Grown only about Albion, N. Y.; not valuable.
77	—	—	—	—	—	—	—	—	—	Tree healthy, hardy and productive. Fruit of high quality but does not ship well.
78	—	—	—	—	—	—	—	—	—	A Fameuse seedling not as good as McIntosh.
79	—	—	—	—	—	—	—	—	—	Not recommended for New York.
80	—	—	—	—	—	—	—	—	—	Excellent in size and quality but not productive enough for a market sort.
81	—	—	—	—	—	—	+	—	—	An Oswego County variety as yet untested elsewhere.
82	—	—	—	—	—	—	—	—	—	A southern apple not recommended for New York.
83	*	*	—	—	—	—	—	—	—	Of highest quality but deficient in size; tree characters poor. A good home sort.
84										Not known outside of Central New York.
85	—	—	—	—	—	—	—	—	—	Probably not known in New York.
86	—	—	—	—	—	—	—	—	—	Trees unproductive, fruit unattractive.
87	—	—	—	—	—	—	—	—	—	An old cider apple now practically obsolete.
88	—	—	*	*	—	—	—	—	—	Fameuse type. Later than Fameuse, otherwise not desirable.
89	—	—	—	—	—	—	—	—	—	Excelled by other varieties both for home use and for market.
90	—	—	—	—	—	—	—	—	—	Valued in the South. Not adapted to New York conditions.
91	—	—	—	—	—	—	—	—	—	Of doubtful value in New York.
92	—	—	—	—	—	—	—	—	—	Unique but not valuable.
93	—	—	—	—	—	—	—	—	—	Obsolete in New York.
94	—	—	—	—	—	—	—	—	—	Now practically obsolete.
95	—	—	—	—	—	—	—	—	—	Not recommended for New York.
96										Tree characters good. Suitable for home rather than market.
97										Probably not known in New York.
98	—	—	—	—	—	—	—	—	—	Oldenburg type but inferior to that variety.
99	—	—	—	—	—	—	—	—	—	An old inferior variety fast becoming obsolete.
100	*	*	—	*	*	*	*	*	*	Attractive, good quality, easily bruised; excellent for the home.
101	—	—	—	—	—	—	—	—	—	Obsolete.
102	—	—	—	—	—	—	—	—	—	Known locally only.
103	—	—	—	—	—	—	—	—	—	A western sort not known in New York.
104	—	—	—	—	—	—	—	—	—	But little grown in this State.
105	—	—	—	—	—	—	—	—	—	Ben Davis class. Not valuable here.

No.	Variety.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
106	Cogswell	m	r c	y r s	m sa	f—g	Dec., Mar.	d	h	Conn.
107	Collamer	A red strain of Twenty Ounce.								
108	Collins	l—m	r o	y r s	sa	f—g	Jan., June	k	m	Ark.
109	Colton	m	r	g y bl	m sa	f—g	July, Sept.	k	h	Mass.
110	Colvert	l	o c	g y r s	sa	g	Oct., Jan.	k	m	Am.
111	Constantine	l—vl	r c	g y r s	b sa	f—g	Sept., Nov.	k	m	Rus.
112	Cooper	l	r o	g y r s	sa	g	Oct., Dec.	k	h	Unk.
113	Cooper Market	m	r ov	y g r s	b sa	f—g	Jan., June	k	m	Pa.
114	Cornell	l—m	r o c	y r s	m sa	vg	Sept., Nov.	d	h	Pa.
115	Corner	m—l	o	y r s	m sa	vg	Nov., Dec.	d	h	N. Y.
116	Cox Orange	m	r o	y r s	m sa	vg—b	Sept., Jan.	d	h	Eng.
117	Cranberry Pippin	l	r o	y r s	m sa	g	Oct., Feb.	k	m	N. Y.
118	Cream	m	r o	y	m sa	s	Sept., Oct.	d k	h	N. Y.
119	Crotts	m—l	r ob	g r s	m sa	f—g	Jan., May	d	h	Kan.
120	Crow Egg	m	r o	y g	s	g—vg	Oct., Nov.	d	h	Ind.?
121	Crowns	l	r c	y g b	b sa	g	Nov., Feb.	k	h m	Unk.
122	Czar Thorn	m	r c	g y r s	s	f	Sept.	k	h	Rus.
123	Danvers *Sweet*	m—l	r c	g y b	s	g—vg	Nov., Apr.	d k	h	Mass.
124	Deacon Jones	l—vl	r c	y r	m sa	f—g	Nov., Mar.	k	m	Pa.
125	Deaderick	l	r	g y bl	sa	g	Oct., Jan.	k	h	Tenn.
126	Detroit Red	l	r o c	r s	m sa	g—vg	Sept., Dec.	d	h	Am.
127	Dickinson	m—l	ob c	y g r s	sa	f—g	Nov., Apr.	k	m	Pa.
128	Disharoon	m	r c	y g	sa	g	Nov., Dec.	k	h	Ga.
129	Doctor	m—l	o	y r s	m sa	g—vg	Dec., Apr.	d k	m	Pa.
130	Doctor Walker	m	r c	g y r s	m sa	g	Jan., May	d k	h	Ky.
131	Domine	m	o	g y r s	m sa	g—vg	Nov., Mar.	d k	h	Am.
132	Double Rose	s	r ob c	y r	m sa	f—g	Nov., Feb.	k	h	Rus.
133	Du Bois	m	o	y r s	m sa	g	Feb., June	k	h	N. Y.
134	Dudley	m—l	r c	y r s	b sa	vg	Sept., Oct.	k	m	Me.
135	Duke of Devons're	m—s	o c	y b ry	sa	g—vg	Dec., Apr.	d k	h	Eng.
136	Dumelow	m—l	r o	y r s	b sa	g	Nov., Mar.	k	m	Eng.
137	Duncan	s—m	r	y r s	m sa	g—vg	Jan., May	d	h	Eng.?
138	Dutch Mignonne	m	r o	y r s	b sa	g	Jan., Apr.	d k	h	Eu.
139	Duzenbury	m	r ob c	g y r s	sa	vg	Feb., May	d k	h	N. Y.
140	Dyer	m—l	r o	g y bl	m sa	vg—b	Sept., Oct.	d	h	Unk.
141	Early Harvest	m	r o	y	sa	g—vg	July, Aug.	d	h	Am.?
142	Early Joe	s—m	o c	g y r s	m sa	vg—b	Aug., Sept.	d	h	N. Y.
143	Early Pennock	l	r	y r s	sa	f—g	Aug.	k	h	Unk.
144	Early Ripe	m	r o	y g	sa	f—g	Aug.	k	h	Unk.
145	Early Strawberry	m	r c	y r s	sa	vg	Aug.	d	h	N. Y
146	Edwards	m	o	y g r s	b sa	g	Feb., May	k	h	N. C.?
147	Egg Top	m	ob c	y r s	sa	f—g	Nov., Dec.	d	h	Unk.
148	Eiser	m	r c	y r s	m sa	g	Jan., June	k	m	Ger.
149	Elgin Pippin	l—m	r o c	y	sa	g	Sept., Dec.	k	h	Ala
150	Ellsworth	m	r	y b	b sa	vg—b	Jan., Mar.	d	h	N. Y
151	English Pippin	l	r o c	g y	sa	f—g	Sept., Nov.	k	h	Rus

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastern Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	REMARKS.
106	—	—	—	—	—	—	—	—	—	Tree hardy and vigorous but unproductive. Fruit not equal to standard sorts of its class.
107										
108										A southern apple. Productive. May prove valuable where Ben Davis thrives.
109	—	—	—	—	—	—	—	—	—	Of little value in New York.
110	—	—	—	—	—	—	—	—	—	Trees hardy, healthy, productive. Inferior to Twenty Ounce with which it ripens.
111	—	+	*	+	+	+	+	+	+	Tree and fruit characters good. Worthy of testing for market.
112	—	—	—	—	—	—	—	—	—	Not recommended for New York.
113	*	*	—	—	—	—	*	—	—	Tree hardy, productive. Fruit lacking in size and quality Splendid keeper.
114										But little known in New York.
115										Known locally only in Orange County.
116	*	*				+	+	+	+	Desirable for the home orchard.
117			+	+						Tree and fruit characters variable. Worth testing in the North.
118	—	—	—	—	—	—	—	—	—	No longer cultivated.
119	—	—	—	—	—	—	—	—	—	A Rambo seedling worthless in New York.
120	—	—	—	—	—	—	—	—	—	Now practically obsolete.
121	—	—	—	—	—	—	—	—	—	Fall Pippin type but not equal to that variety.
122	—	—	—	—	—	—	—	—	—	Of no value.
123	—	—	—	—	—	—	—	—	—	Tree vigorous and productive. Fruit of good size and quality but unattractive color.
124						+	+	+		An attractive market fruit of inferior quality. Heavy bearer.
125										Tree characters good but fruit inferior. Not tested sufficiently.
126	—	—	—	—	—	—	—	—	—	Of Fameuse type. Surpassed by McIntosh.
127	—	—	—	—	—	—	—	—	—	Poor grower, very productive. Second rate quality.
128	—	—	—	—	—	—	—	—	—	A southern apple not recommended for New York.
129	—	—	—	—	—	—	—	—	—	Tree characters desirable. Fruit attractive, of good size and quality.
130	—	—	—	—	—	—	—	—	—	Not recommend for planting in New York.
131	*	*	—	—	—	—	—	—	—	Wood very brittle. Productive. Fruit small. Not grown as much as formerly.
132	—	—	—	—	—	—	—	—	—	Small and poor in quality.
133										A Columbia County seedling of Blue Pearmain type. Of doubtful value.
134			+	+						Recommended for trial where a hardy apple is wanted.
135	—	—	—	—	—	—	—	—	—	Productive, small size, drops badly, high quality. Surpassed by others of its class.
136	—	—	—	—	—	—	—	—	—	A standard English culinary apple, of dobutful value in New York.
137	—	—	—	—	—	—	—	—	—	Too small for a commercial apple.
138	—	—	—	—	—	—	—	—	—	Tree vigorous, very productive. Fruit too small except for home use and evaporators.
139	—	—	—	—	—	—	—	—	—	Little known outside of Putnam County where it originated.
140	—	—	—	—	—	—	—	—	—	One of the finest dessert apples but not a good commercial variety.
141	*	*				*	*	*	*	Tree characters poor. Valuable only as an early dessert apple.
142	*	*				*	*	*	*	Of value for the home orchard only. High quality.
143	—	—	—	—	—	—	—	—	—	Discarded in New York.
144	—	—	—	—	—	—	—	—	—	Surpassed by others of its season.
145	*	*		*	*	*	*	*	*	Its high quality makes it a desirable home sort.
146	—	—	—	—	—	—	—	—	—	Not well adapted for growing as far north as this State.
147	—	—	—	—	—	—	—	—	—	Nearly obsolete.
148	+	+	+	+	+	+	+	+	+	A European variety worthy of further testing. Attractive, excellent keeper.
149	—	—	—	—	—	—	—	—	—	Does not equal other varieties of its season.
150	—	—	—	—	—	—	—	—	—	Not grown outside of Columbia County.
151	—	—	—	—	—	—	—	—	—	Inferior to standard varieties.

No.	Variety.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
152	English Russet...	m	r c	g y ru	m sa	g	Jan., May	d c	h m	Unk.
153	Esopus *Spitzenburg*	m—l	r c	y r s	sa	vg—b	Nov., Feb.	d k	h m	N. Y.
154	Evening Party ...	m	r o	g y r s	m sa	vg—b	Dec., Jan.	d	h	Pa.
155	Ewalt...........	l	r c	y r s	b sa	g	Nov., Apr.	k	m	Pa.
156	Falix............	m	o c	g y r s	m sa	g	Nov., Apr.	k	h	Unk.
157	Fallawater.......	l—vl	r	g y b	m sa	g	Nov., Mar.	k	m	Pa.
158	Fall Greening.....	m	r o	g y	sa	g—vg	Dec., Feb.	d	h	N. Y.
159	Fall Harvey......	l	r	y	sa	vg	Oct., Dec.	d	h	Mass.
160	Fall Jenneting....	l—m	r o c	g y	sa	g	Sept., Dec.	d k	h	Conn.?
161	Fall Orange......	l—m	r c	g y	sa	vg	Sept., Nov.	d k	h	Unk.
162	Fall Pippin......	l—vl	r o	g y	sa	vg	Sept., Jan.	d k	l m	Am.
163	Fall Wine........	m	r o	y r s	m sa	vg	Sept., Jan.	d	h	Unk.
164	Fameuse.........	m	r	y r s	sa	vg	Oct., Dec.	d	m	Unk.
165	Family..........	s—m	r ov	y r s	b sa	g	Oct., Jan.	d k	h	Ga.
166	Fanny...........	m	r	y r s	m sa	g—vg	Sept., Nov.	d	h	Pa.
167	Farris...........	m	r o	y r s	sa	g	Dec., Mar.	d	h	Ky.
168	Ferdinand.......	m—l	r c	y g b	sa	g—vg	Dec., May	d	h	S. C.
169	Fishkill..........	l—vl	r	y r	m sa	f—g	Nov., Feb.	k	m	N. Y.
170	Florence.........	m	r o v	y w r s	sa	g—vg	Dec., May	d k	m	Ark.
171	Flory............	m	r c	y	sa	g	Oct., Feb.	k	m	O.
172	Flushing *Spitzenburg*	m—l	r c	y g r	m sa	g	Oct., Feb.	k	m	Am.
173	Ford............	l	r c	y	b sa	g	Oct., Jan.	k	h	N. Y.
174	Forest...........	m	r ob c	y r s	m sa	vg	Dec., Mar.	d	h	N. Y.
175	Fraker..........	m	r c	y r s	m sa	g	Dec., Apr.	d	h	Kan.
176	Franchot........	m	r c	y r s	sa	g	Oct., Jan.	k	h	N. Y.
177	French Pippin....	l—vl	r	y b	sa	v—vg	Jan., May	k	m	Unk.
178	Fullerton Sweet..	m	r c	y	s	vg	Oct., Nov.	d	h	N. Y.
179	Gano............	m	r c	y r s	m sa	g	Dec., Apr.	k	m	Unk.
180	Garden Royal....	m	r o	g y r s	m sa	vg	Aug., Sept.	d	h	Mass.
181	Gardner Sweet Pearmain.......	m	o	y r s	s	g	Sept.	d	h	N. Y.
182	Genesee Flower...	l	r o	y g	m sa	g	Sept., Nov.	k	h	N. Y.
183	Gideon..........	l—m	r c	y	sa	f—g	Oct. .	k	m	Minn.
184	Gideon Sweet....	m—l	r c	y g r s	s	g—vg	Nov., Apr.	d k	h m	Minn.
185	Gilpin...........	m	r ov	g y b	m sa	g	Feb., June	c k	h	Va.?
186	Ginnie...........	m—l	o c	y r s	sa	g—vg	Sept., Nov.	d	h	Unk.
187	Givens..........	m	orc	y g r s	m sa	g	Jan., May	k	m	Ark.
188	Gladstone........	m—l	r o c	g y r	m sa	f	Sept., Oct.	k	h	Eng.
189	Glenlock.........	l	r o	y r s	m sa	g	Dec., Feb.	k	m	Tenn.
190	Gloria Mundi.....	l—vl	r c	g y	m sa	f—g	Oct., Jan.	k	h	Am.
191	Golden Medal....	m—l	r o	y g b	s	f—g	Dec., May	k	m	Pa.?
192	(I) Golden Pippin.	l—vl	r o	g y	m sa	g—vg	Sept., Dec.	d k	m	Unk.
193	(II) Golden Pippin	l	r o	g y b l	sa	g	Sept., Oct.	k	h	Mass.
194	Golden Red......	m—s	r o	y r s	m sa	g	Dec., Jan.	d	h	N. Y.
195	Golden Reinette..	s	r o	g y r s	b sa	g	Oct., Jan.	d	h	Eu.
196	Golden Reinette (Russ.).........	m	o c	g y	m sa	g	Sept., Dec.	k	h	Russ.
197	Golden Russet....	m	r	g y ru	sa	vg	Dec., Apr.	c d k	h m	Eng.?
198	Golden Sweet....	m—l	r o	y g	s	g—vg	Aug. Sept.	d	h	Unk.
199	Golden White....	m	o c	g y r	s	f—g	Sept., Oct.	k	h	Russ.

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastern Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	REMARKS.
152	*	*	—	—	—	—	—	—	—	Desirable in Eastern New York. Grown for export trade.
153	*	**	—	**	**	*	*	*	*	Lacks vigor. Uncertain productiveness. Standard in quality. Adapted to some localities.
154	—	—	—	—	—	—	—	—	—	Fruit small but of high quality. Suitable for home only.
155	—	—	—	—	—	—	—	—	—	Tree uncertain bearer. Fruit characteristics desirable.
156	—	—	—	—	—	—	—	—	—	Not recommended even for trial.
157	**	*	—	—	—	—	—	—	—	Vigorous and productive. Fruit inferior in quality. Valuable for market in some localities.
158	—	—	—	—	—	—	—	—	—	Two of this name. Neither worthy of consideration.
159	—	—	+	—	—	—	—	—	—	Resembles Fall Pippin; is less desirable. Very hardy.
160	—	—	—	—	—	—	—	—	—	Good grower, good cropper, of fair quality but easily bruised and poor color.
161	—	—	—	—	—	—	—	—	—	Tree thrifty, hardy, long lived, good cropper. Fruit too tender and wrong color for market.
162	**	**	—	—	—	**	**	**	**	Old standard variety; scabs badly. An excellent green apple for certain localities.
163	—	—	—	—	—	—	—	—	—	Although of excellent quality, not valuable commercially.
164	—	—	**	**	—	—	—	—	—	Hardy, fair grower, good cropper. Fruit scabs badly, very tender and rather small.
165	—	—	—	—	—	—	—	—	—	Not desirable in New York.
166	*	*				*	*	*	*	Rather vigorous, reliable cropper. Fruit bright red, good quality. Rather small.
167	—	—	—	—	—	—	—	—	—	Too unattractive in color and size to be desirable.
168	+	+	—	—	—	—	—	—	—	May be worth planting in home orchards of southeastern New York.
169			+	+	+					Worthy of trial in certain localities.
170										May prove valuable in those parts of the State where Ben Davis does well.
171	—	—	—	—	—	—	—	—	—	Only moderately productive. Not recommended for New York.
172	—	—	—	—	—	—	—	—	—	Tree a shy bearer. Fruit drops badly. Handsome but second rate quality.
173	—	—	—	—	—	—	—	—	—	No longer propagated.
174	—	—	—	—	—	—	—	—	—	A chance seedling of doubtful value.
175	—	—	—	—	—	—	—	—	—	Surpassed by standard varieties.
176	—	—	—	—	—	—	—	—	—	Undesirable.
177	—	—	—	—	—	—	—	—	—	Not being planted in New York.
178	—	—	—	—	—	—	—	—	—	Without value.
179	+	+	—	—	—	+	+			May prove valuable where Ben Davis thrives.
180	*	*				*	*	*	*	Good dessert sort but too small for market.
181	—	—	—	—	—	—	—	—	—	No longer propagated.
182						*	*		*	Confined to western New York. Of local value only.
183	—	—	—	—	—	—	—	—	—	Of value only as a stock upon which to topwork hardy sorts.
184			+							One of Gideon's new promising varieties.
185	—	—	—	—	—	—	—	—	—	An old very late keeping variety too small to be valuable commercially.
186	—	—	—	—	—	—	—	—	—	Unknown in New York. Unworthy.
187										It may be worthy of testing for commercial purposes where Ben Davis succeeds.
188	—	—	—	—	—	—	—	—	—	Not recommended for planting in New York.
189	—	—	—	—	—	—	—	—	—	Tennessee variety not promising in New York.
190	—	—	—	—	—	—	—	—	—	Cultivated for exhibition purposes only.
191										May be worth trial where a late keeping sweet apple is desired.
192	*	*	—	—	—	*	*	*	*	One of the most desirable fall sorts for market.
193	—	—	—	—	—	—	—	—	—	No longer grown in New York.
194	—	—	—	—	—	—	—	—	—	A Long Island variety now apparently obsolete.
195	—	—	—	—	—	—	—	—	—	Highly esteemed in England but little known in New York.
196	—	—	—	—	—	—	—	—	—	May be of value in the North.
197	*	*	—	*	*	*	*	*	*	Tree hardy, vigorous, productive. Fruit small, hard to pick, very late, of excellent quality.
198	*	*	+	*	*	*	*	*	—	One of the best for home use.
199	—	—	—	—	—	—	—	—	—	Not desirable.

No.	Variety.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
200	Golding	m	r o c	y	sa	g—vg	Oct.	d k	h	Am.
201	Grandmother	m—l	r ov c	g y b l	sa	f—g	Nov., Jan.	k	h	Rus.
202	Granite Beauty...	l	ro b	y r s	m sa	g—vg	Nov., Feb.	d	h	N. H.
203	Gravenstein......	l	o	y r s	sa	vg—b	Sept., Nov.	d k	m	Eu.
204	Great Barbe......	l		y r		f—g	Dec., Jan.	k	m	Rus.
205	Great Mogul......	l	r ov	g y r s	sa	f—g	Oct., Dec.	k	h	Rus.
206	Green and Yellow Newtown	m—vl	r o	g y	sa	b	Feb., May	d k	h m	N. Y.
207	Green Seek-No-Further	l	r c	y bl	sa	vg	Oct., Jan.	d	h	N. Y.?
208	Green Sweet......	m	r ov	y g	s	g	Dec., May	k	l m	Am.
209	Greenville.........	l—m	r	y b	m sa	g	Nov., Feb.	k	m	O.
210	Greyhouse........	m	o	g r	sa	f—g	Feb., May	k	m	Am.
211	Grimes..........	m—l	r ob	y	sa	vg—b	Nov., Feb.	d k	h m	W. Va.
212	Grosh...........	l—vl	r o—	g y r s	b sa	g—vg.	Sept., Jan.	k	m	Unk.
213	Grundy	l	r ob	y r	sa	vg	Sept., Oct.	k	h	Ia.
214	Haas............	m	o	y r s	b sa	f	Oct., Dec.	k	h	Mo.
215	Hagloe...........	m—l	r c	g y r s	b sa	g	Aug., Sept.	k	h	Am.?
216	Hargrove.........	s—m	r c	y	m sa	g	Nov., Mar.	k	h	N. C.
217	Harvest Redstreak	m	o	y r s	b sa	g	Aug., Sept.	k	h	Unk.
218	Haskell..........	l—m	r o	g y	s	vg	Sept., Dec.	d	h	Mass.
219	Hawley..........	l—vl	r	g y	m sa	vg	Sept., Nov.	d	h	N. Y.
220	Hawthornden....	m—l	r	w y bl	sa	g	Sept.	k	h	Scot.
221	Haywood........	m	o	y r s	m sa	f	Dec., Jan.	k	m	N. C.
222	Hazen...........	m	r	y g	s	f—g	Dec., Apr	k	m	Vt.
223	Henniker........	m—l	r o	y r s	sa	g—vg	Nov., Mar.	k d	h	Eng.
224	Herefordshire....	m	r o	g y r	sa	f—g	Oct., Jan.	k	m	Eng.
225	Hibernal.........	l	o	g y r s	b sa	g	Nov., Dec.	k	m	Rus.
226	Hicks...........	m	r	y r s	s	vg	Aug.	d	h	N. Y.
227	Hiester..........	m	r o	y r s	m sa	f—g	Dec., Feb.	k	h	Pa.
228	Highland Beauty.	s	o	y b	m sa	vg	Jan., Mar.	d	h	N. Y.
229	Hightop Sweet...	m—s	r o	y	s	vg	July, Aug.	d	h	Unk.
230	Hilaire..........	m	o	y r s	sa	g—vg	Nov., Jan.	d	h	Can.
231	Hilton...........	l	r	y g	sa	g	Sept., Oct.	k	h	N. Y.
232	Hoadley.........	l	r o	g y r s	b sa	g	Sept., Nov.	k	h	Wis.?
233	Hog Island Sweet.	m—l	r c	g y r s	s	g vg	Sept., Nov.	d	h	N. Y.
234	Holland Pippin...	l—vl	r	g y	b sa	g	Sept., Oct.	k	h	Am.
235	Holland Winter...	m—l	r c	g w b	sa	g	Dec., May	k	m	Eng.?
236	Holmes Sweet....	m	r c	y b	s	vg	Nov., Feb.	d	h	N. Y.
237	Hook...........	m	r ob c	g y	m sa	vg	Oct., Nov.	d	h	N. Y.?
238	Howard Best.....	l	o c	y g r s	sa	f—g	Sept., Oct.	k	m	Ia.?
239	Hubbardston.....	l	r c	y r s	m sa	vg—b	Oct., Jan.	d k	m	Mass.
240	Hunter Pippin....	m	r c	w y	b sa	g	Aug.	k	h	N. Y.
241	Hunt Russet.....	m	o	y r ru	sa	vg—b	Jan., Apr.	d	h	Mass.
242	Huntsman........	l	r o	y g b	sa	g—vg	Dec., Apr.	d k	h m	Mo.
243	Hurlbut	m	r o c	g y r s	m sa	g—vg	Oct., Dec.	d	h	Conn.
244	Hyde King.......	l—vl	r	y g b	m sa	g	Dec., May	k	m	Unk.
245	Ingram..........	m	r o	g y r s	m sa	g—vg	Feb., June	d k	h m	Mo.
246	Isham...........	m	r c	y g r s	s	g—vg	Oct., Dec.	d	h	Wis.
247	Jack............	m—l	o	g y	m sa	vg	Oct., Nov.	d	h	N. Y. ?
248	Jackson.........	m	r	g y r s	m sa	g	Oct., Feb.	d	h	Pa.
249	Jacobs Sweet.....	l	r c	y g b	s	g	Oct., Mar.	d	l m	Mass.
250	Jarvis...........	l	r	y r s	sa	g	Sept., Nov.	k	h	N. Y.
251	Jefferis..........	s—m	r o	g y r s	m sa	vg	Sept., Jan.	d	h	Pa.
252	Jefferson County..	m	r o c	y r	sa	g—vg	Oct., Nov.	d	h	N. Y.

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastern Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	REMARKS.
200	—	—	—	—	—	—	—	—	—	Seldom or never planted in New York.
201	—	—	—	—	—	—	—	—	—	Of little or no value in New York.
202	—	—	—	—	—	—	—	—	—	A New England variety but little known in New York.
203	*	**	*	**	*	**	**	*	*	Bears early, productive, vigorous. Fruit attractive and excellent. Becoming popular.
204	—	—	—	—	—	—	—	—	—	As tested here not worthy of introduction into New York.
205	—	—	—	—	—	—	—	—	—	Not recommended for New York.
206	**	**	—	—	—	—	—	—	—	Standard in quality. Succeeds in certain localities only. Weak grower.
207	—	—	—	—	—	—	—	—	—	Now seldom found in cultivation in New York.
208	—	—	—	—	—	*	*	—	—	An old variety grown only for local markets.
209										Suitable for general market but does not excel in quality.
210	—	—	—	—	—	—	—	—	—	An old variety, not now generally cultivated. Not reliable bearers.
211	*	*	—	—	—	—	—	—	—	Beautiful and of high quality but not adapted to latitude of New York.
212		+	—	+	+	+	+	+	+	Worthy of further testing.
213	—	—	—	—	—	—	—	—	—	Of very doubtful value.
214	—	—	—	—	—	—	—	—	—	Supplanted by better kinds.
215	—	—	—	—	—	—	—	—	—	Not worth planting in New York.
216	—	—	—	—	—	—	—	—	—	Does not appear to be worthy of trial in New York.
217	—	—	—	—	—	—	—	—	—	Not attractive in any particular.
218	*	*			*	*	*	*	*	Desirable for the home orchard.
219	*	*			*	*	*	*	*	A handsome apple of delicious quality but poor tree characters.
220	—	—	—	—	—	—	—	—	—	Little known. Not worthy of introduction.
221	—	—	—	—	—	—	—	—	—	Not desirable for planting in New York.
222	—	—	—	—	—	—	—	—	—	Not recommended for New York.
223	—	—	—	—	—	—	—	—	—	Not recommended for planting in New York.
224	—	—	—	—	—	—	—	—	—	Does not appear to be worthy of trial in New York.
225	—	—	*	—	—	—	—	—	—	Withstands the most vigorous climate, productive, fine for cooking.
226	—	—	—	—	—	—	—	—	—	Not recommended.
227	—	—	—	—	—	—	—	—	—	Not recommended for planting in New York.
228	—	—	—	—	—	—	—	—	—	Lady type. Suitable for localities where that variety is known.
229	—	—	—	—	—	—	—	—	—	Should be dropped from cultivation.
230			+	+	+					Worthy of trial in Fameuse regions.
231	—	—	—	—	—	—	—	—	—	Passing out of cultivation.
232		+	+	+	+	+	+	+	+	Worthy of testing where the Oldenburg thrives.
233	—	—	—	—	—	—	—	—	—	Little known and unworthy.
234	*	*	—	—	—	—	—	—	—	An old sort in Hudson Valley. Resembles Fall Pippin but poorer quality.
235	—	—	—	—	—	—	—	—	—	Greening type. May be worthy of trial. Keeps well.
36	—	—	—	—	—	—	—	—	—	A Niagara County seedling now practically obsolete.
237	—	—	—	—	—	—	—	—	—	Known only locally.
238										Resembles Alexander. Not yet well tested in New York.
239	**	**	—	*	**	**	**	**	**	Tree an early bearer, productive, not hardy. Fruit handsome and of highest quality.
240	—	—	—	—	—	—	—	—	—	Of no commercial value.
241	—	—	—	—	—	—	—	—	—	Superseded by more valuable russet kinds.
242	+									Quality excellent but of doubtful value in New York.
243	—	—	—	—	—	—	—	—	—	Not being planted to any considerable extent.
244	+	+	+	+	+	+	+	+	+	Promising as a commercial sort as grown at this Station.
245	—	—	—	—	—	—	—	—	—	A seedling of and similar to Ralls.
246	—	—	—	—	—	—	—	—	—	Not desirable.
247	—	—	—	—	—	—	—	—	—	Neither tree nor fruit characters are desirable.
248	—	—	—	—	—	—	—	—	—	Not recommended for planting in New York.
249	*	*			*	*	*	*		Recommended for home orchards, not for commercial planting.
250	—	—	—	—	—	—	—	—	—	Not recommended.
251	*	*				*	*	*	*	Excellent for the home orchard.
252	—	—	—	—	—	—	—	—	—	Not worth planting.

No.	Variety.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
253	Jersey Sweet.....	m	r c	y r s	s	g—vg	Sept., Dec.	d	h	Unk.
254	Jewett *Red*.......	m	r o	y r s	m sa	g—vg	Oct., Feb.	d	h lm	N. H.
255	Jonathan........	m	r c	y r s	sa	vg—b	Nov., Jan.	d k	h m	N. Y.
256	Jonathan Buler...	l—m	o	y g r s	m sa	f—g	Nov., Apr.	k	m	Ill.?
257	Judson..........	vl—l	r c	y r s	b sa	f—g	Oct., Nov.	k	m	Ia.
258	July............	m	r c....	w y r s	sa	f—g	July, Sept.	k	h	Rus.
259	Kaighn..........	l	ob c	y r s	sa	g	Nov., Jan.	k	h	N. J.
260	Kalidon.........	l—m	o c	g y r s	m sa	f—g	Sept., Jan.	k	h	Rus.
261	Kansas Greening..	m	r c	g b	m sa	f—g	Jan., Apr.	k	m	Kan.
262	Kansas Keeper...	m—l	r	y g r s	sa	f—g	Dec., June	k	m	Kan.?
263	Karabovka......	s—m	o	g y r s	m sa	f—g	Aug., Sept.	k	h	Rus.
264	Kentish Fillbasket	vl	r o	y bl	b sa	g	Oct., Dec.	k	h	Eng.
265	Keswick.........	m—l	r c	g y	b sa	g	Aug., Sept.	k	h	Eng.
266	Kinnaird........	m	r	y r	sa	g—vg	Dec., Mar.	d k	h	Tenn.
267	Kirkbridge.......	s—m	ob c	y w	sa	g—vg	Aug., Sept.	d	h	Am.
268	Kirkland........	l—m	r c	y b	sa	g	Jan., May	k	m	N. Y.
269	Kittageskee......	s—m	r o c	y b	m sa	vg	Dec., May	d	h	N. C.?
270	Lacker..........	m—l	r o	y g r s	m sa	g—vg	Dec., May	d	h	Pa.
271	Lady...........	s—vs	o	y b	sa	g—vg	Dec., May	d	h lm	Fr.
272	Lady Finger.....									
273	Lady Finger.....	m	r c	y r	sa	g—vg	Aug.	d	h	Unk.
274	Lady Sweet......	l—m	r c	y g r s	s	vg—b	Nov., Apr.	d k	m	N. Y.
275	Landon..........	m—l	r o c	y r s	m sa	g—vg	Dec., May	d	h	Vt.
276	Landsberg.......	m—l	r c	g y	m sa	g—vg	Oct., Jan.	d	h	Ger.
277	Lankford........	m	r o	g y r s	m sa	f—g	Dec., May	k	h	Md.
278	Lansingburg.....	m	r o	y g r s	m sa	f—g	Dec., May	k	m	O.
279	Late Strawberry..	m	r ob c	y r s	sa	vg	Sept., Dec.	d	h	N. Y.
280	Latham.........	m	o c	y r	m sa	g	Nov., Dec.	k	h	N. Y.
281	La Victoire......	l—m	o c	g y r s	m sa	g	Nov., Dec.	d	h	Can.
282	Lawver.........	m	r o	r	b sa	f—g	Jan., May	k	m	Kan.?
283	Lead...........	m	o c	g y r s	sa	f	Aug., Sept.	k	h	Rus.
284	Lee Sweet.......	m—l	r ob c	y r s	s	g	Jan., Apr.	k	m	N. Y.?
285	Lehigh *Greening*..	m—l	r o c	y g	m sa	g	Jan., May	k	m	Pa.?
286	Lilly of Kent.....	l	r	y g	sa	g	Jan., May	d	m	Del.
287	Limbertwig (small or red)........	m	r o c	y r s	sa	g	Jan., Apr.	k	m	Unk.
288	Limbertwig (large or green).......	Larger, greener and less attractive in color than the above, coarser.								
289	Lincoln Pippin...	m	r o c	g y	sa	vg	Oct., Dec.	d	h	Conn.
290	Lindenwald......	m	r o	y bl	sa	g—vg	Sept.	d	h	N. Y.
291	Longfield........	m—s	r c	y bl	sa	g—vg	Sept., Oct.	d	h	Rus.
292	L. Isl'd Pearmain.	l	ob	y r s	sa	g	Oct., Jan.	d	h	Unk.
293	(I) L. Isl'd Russet	s	ob c	y r u	m sa	g	Oct., Feb.	c d	h	N. Y.
294	(II) L. I. Russet..	m—s	r ob c	y r u	b sa	vg	Nov., Jan.	c d	h	Unk.
295	Long Red Pearm'n	m—l	o c	y r s	sa	g	Nov., Dec.	k	h	Unk.
296	Long Stem.......	Several varieties under this name, all worthless.								
297	Long Stem of Pa..	m	r	y g r s	b sa	g—vg	Nov., Feb.	d	h	Pa.
298	Longworth.......	m	r o c	w y r s	m sa	vg	Nov., Feb.	d	h	Ia.
299	Lord Suffield.....	l	r	y	sa	g	July, Sept.	k	h	Eng.
300	Lou.............	m—l	r	y r s	sa	f—g	Aug.	k	h	Minn.
301	Louise..........	m	r	g y bl	sa	vg	Oct., Feb.	d	h	Can.
302	Lowell..........	l	r ob	y	sa	g—vg	Aug., Oct.	d k	lm	Am.
303	Lowland Raspb'ry	m—l	r c	w r s	m sa	vg	Aug.	d	h	Rus.
304	Lubsk Queen.....	m—l	r	w r	sa	g	Aug., Sept.	k	h	Rus.
305	Lyscom..........	l—vl	r	y g r s	sa	g	Oct., Dec.	k	h	Mass.
306	Mabie...........	l—m	r ob	y r s	s	g	Nov., Dec.	k	h	N. Y.
307	McAfee..........	m—l	r o	y r s	m sa	g—vg	Oct., Feb.	k	m	Ky.
308	McCarty.........	A strain of Pumpkin Sweet. Smaller and keeps longer.								
309	MacDonough.....	m	r o	y	m sa	f—g	Aug., Sept.	k	h	N. Y.
310	McIntosh........	m—l	r	y r s	m sa	vg—b	Oct., Dec.	d	m	Can.
311	McKinley........	m—l	r o	y r s	sa	g	Dec., Jan.	d	h	Ind.

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastern Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	REMARKS.
253	*	*			*	*	*	*	*	One of the best sweet apples for home use.
254	—	—	*	*	—	—	—	—	—	One of the best in quality of the Blue Pearmain type.
255	**	**	—	—	*	—	—	—	—	Excellent quality but rather small for a commercial variety.
256	—	—	—	—	—	—	—	—	—	Tree good. Fruit attractive in size and color but lacking in quality.
257	—	—	—	—	—	—	—	—	—	Not worthy of trial.
258	—	—	—	—	—	—	—	—	—	Inferior to Tetofsky, which it resembles.
259	—	—	—	—	—	—	—	—	—	Obsolete.
260	—	—	—	—	—	—	—	—	—	Very inferior.
261	—	—	—	—	—	—	—	—	—	Not worthy of planting in New York.
262	—	—	—	—	—	—	—	—	—	A late keeper. Succeeds better in southern latitudes.
263	—	—	—	—	—	—	—	—	—	Unworthy.
264	—	—	—	—	—	—	—	—	—	Many worthier sorts of its season.
265	*	*				*	*	*	*	Suitable for home use only.
266	—	—	—	—	—	—	—	—	—	Winesap type. Does not appear to be adapted to New York.
267	—	—	—	—	—	—	—	—	—	Not recommended.
268				*		+				Tree characters good. Fruit of good color and keeps well. Worthy of attention.
269										A worthy late keeping dessert apple for home use.
270	—	—	—	—	—	—	—	—	—	Gradually passing out of cultivation.
271	*	*	—	—	—	—	—	—	—	A beautiful fancy apple suitable for special trade.
272	—	—	—	—	—	—	—	—	—	Several varieties under this name. Not valuable.
273	—	—	—	—	—	—	—	—	—	Of no value.
274	*	**	—	*	*	*	*	*	*	One of the most desirable of the sweet apples for commercial planting.
275	—	—	—	—	—	—	—	—	—	Shy bearer. Good color and size.
276	—	—	—	—	—	—	—	—	—	Excelled by standard sorts.
277	—	—	—	—	—	—	—	—	—	Easily excelled by standard varieties.
278	—	—	—	—	—	—	—	—	—	Very late keeper but poor in quality.
279	*	**				**	*	*	*	One of the best dessert apples of its season.
280	—	—	—	—	—	—	—	—	—	Obsolete.
281	—	—	—	—	—	—	—	—	—	A seedling of Fameuse inferior to McIntosh.
282	—	—	—	—	—	—	—	—	—	Better adapted to southern latitudes.
283	—	—	—	—	—	—	—	—	—	Unworthy of further testing.
284						+	+		+	Grown about Geneva where it is held in high esteem.
285	—	—	—	—	—	—	—	—	—	Surpassed by other sorts of its class.
286										Not sufficiently tested in New York.
287	—	—	—	—	—	—	—	—	—	A southern variety not adapted to New York.
288										More juicy and much inferior in flavor and quality.
289										Grown only about Syracuse.
290										Known only in Columbia County.
291	*	*	*	*	*	*	*	—	—	Recommended for home use and local markets.
292	—	—	—	—	—	—	—	—	—	Obsolete.
293	—	—	—	—	—	—	—	—	—	Now nearly obsolete.
294	—	—	—	—	—	—	—	—	—	Represented now only by old trees.
295	—	—	—	—	—	—	—	—	—	Obsolete.
296										
297	—	—	—	—	—	—	—	—	—	Not recommended for New York.
298	—	—	—	—	—	—	—	—	—	Unworthy.
299	—	—	—	—	—	—	—	—	—	So susceptible to blight as to be worthless.
300	—	—	—	—	—	—	—	—	—	Excelled by its parent, Oldenburg.
301	—	+	+	+	+	+	+	+	+	A beautiful and excellent apple for home use. Fameuse type.
302	*	*				*	*	*	*	Desirable for home use and local market.
303										A beautiful dessert fruit. Not tested in New York.
304	—	—	—	—	—	—	—	—	—	Not recommended.
305	—	—	—	—	—	—	—	—	—	Supplanted by better sorts.
306	—	—	—	—	—	—	—	—	—	Surpassed by Victoria Sweet which it resembles.
307	—	—	—	—	—	—	—	—	—	A seedling of Lawver, not adapted to New York.
308										
309	—	—	—	—	—	—	—	—	—	Not likely to become popular.
310		*	**	**	**	**	**	**	*	One of the most promising sorts of it season. Fameuse type.
311	—	—	—	—	—	—	—	—	—	Practically unknown in New York. Not recommended.

No.	Variety.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
312	McKinney	m—l	o	y bl	m sa	g	Jan., Apr.	k	h	N. Y.
313	McLellan	l—m	r o c	g y r s	m sa	vg	Oct., Feb.	d	lm	Conn.
314	McMahon	l—vl	r c	g y w	b sa	f—g	Oct., Jan.	k	m	Wis.
315	Magenta	l—m	o c	y g bl	sa	g—vg	Nov., Mar.	k	lm	Unk.
316	Magog	m—l	r ob	g y r s	sa	g	Oct., Jan.	k	h	Vt.
317	Maiden Blush	m	o	y bl	sa	g	Sept., Nov.	k	m	N. J.?
318	Maiden Favorite	m	r	w y	sa	g—vg	Oct., Jan.	d	h	N. Y.
319	Mala Carle	m	o c	y bl	sa	g	Dec., Feb.	d	h	Italy
320	Malinda	l—m	r c	y bl	m sa	f	Jan., Apr.	k	m	Vt.
321	Manchester	m—l	r bo c	g y r s	b sa	g—vg	Dec., Apr.	d	m	Unk.
322	Mann	m—l	r o	g y	sa	f—g	Jan., Apr.	k	m	N. Y.
323	Margaret	s—m	r c	y r s	sa	g	July, Aug.	d	h	Eng.
324	Marigold	m—l	r	y g bl	m sa	g	Nov., Apr.	d	h	Unk.
325	Mason Orange	m—l	ob c	y bl	sa	g	Nov., Feb.	d k	h	Kan.
326	Masten	m	r c	g y	sa	g	Dec., Feb.	k	h	N. Y.
327	Melon	l—m	r c	y g r s	sa	vg	Oct., Jan.	d	lm	N. Y.
328	Ménagère	l—vl	o c	y bl	sa	f	Oct., Jan.	k	h	Eu.
329	Merrill	m	r	y bl	sa	g	Dec., Mar.	k	h	N. Y.
330	Middle	m	r ob c	g y	b sa	vg	Dec., Mar.	d	h	N. Y.
331	Milam	s—m	r c	y g r s	m sa	g	Nov., Jan.	d	h	Unk.
332	Milden	l—m	o c	y r s	sa	g	Nov., Jan.	d k	h	N. H.
333	Miller	l	r o c	y r s	sa	g—vg	Oct., Nov.	d	h	N. Y.
334	Milligen	l	r	y r s	sa	g—vg	Oct., Jan.	d	h	Pa.
335	Milwaukee	l—m	o	y r s	b sa	f—g	Oct., Jan.	k	m	Wis.
336	Minister	l—m	r ob c	y g r s	b sa	g—vg	Nov., Feb.	d k	h	Mass.
337	Minkler	m	r o c	y g r s	m sa	f—g	Nov., Apr.	k	m	Unk.
338	Missing Link	l	r	g y r	m sa	f	Jan., Apr.	k	m	Unk.
339	Missouri *Pippin*	m	r c	g y r s	b sa	f—g	Oct., Jan.	k	m	Mo.
340	Monmouth	l—m	r o c	y bl	b sa	g—vg	Nov., Jan.	d k	h	N. J.
341	Moon	m	r o	y g bl	m sa	g	Nov., Apr.	k	h	Ga.
342	Moore Sweet	m—l	r o c	y g r	s	g	Nov., Apr.	k	m	Mass.
343	Mosher	m	o c	g y	s	g	Sept., Oct.	d	h	N. Y.
344	Mother	m	r	y r s	m sa	vg—b	Sept., Jan.	d	h	Mass.
345	Mountain Sweet	m	r	y r s	s	g	Sept., Dec.	d	h	Pa.
346	Mouse	l	r c	g y bl	m sa	g	Oct., Nov.	k	h	N. Y.
347	Moyer	l	ob c	y bl	m sa	g—vg	Dec., Apr.	d	lm	Ind.?
348	Munson	m	r o	g y	s	g—vg	Sept., Dec.	d	h	Mass.?
349	Nelson	m	r ob ov	g y bl	s	g	Feb., May	d k	h	Ill.?
350	Nero	m	r c	g y r s	m sa	g—vg	Jan., Apr.	k	m	N. J.
351	Newark Pippin	m—l	r o b	g y	sa	vg—b	Nov., Feb.	d k	h	N. J.?
352	Newman	m—l	o b c	y g bl	m sa	f—g	Dec., May	k	lm	O.?
353	Newtown Spitzenburg	m	r	y r s	m sa	vg—b	Nov., Feb.	d	h	N. Y.
354	New Water	l—m	o c	g y r s	m sa	g	Oct., Feb.	d	h	Pa.?
355	Nickajack	l—m	r c	g y r s	m sa	g	Dec., May	k	m	N. C.
356	Northern Spy	l—vl	r c	y r s	sa	vg—b	Dec., Feb.	d k	m	N. Y.
357	Northern Sweet	m	r o	y	s	vg	Sept., Oct.	d	h	Vt.
358	Northwestern *Greening*	m—l	r c	y g	m sa	g	Dec., Mar.	d k	m	Wis.
359	Oakland	m—l	r o c	g y r s	s	g	Nov., Feb.	d k	h	Mich.
360	Occident	m	r o c	y bl	sa	vg	Jan., May	d k	h	Cal.
361	Oel Austin	m	r c	y r s	m sa	f—g	Nov., Mar.	d k	m	N. Y.
362	Ogdensburg	m	r o c	y	m sa	vg	Nov., Dec.	d	h	N. Y.
363	Ohio Nonpareil	m—l	r o	y r s	sa	g—vg	Oct., Nov.	d	h	O.
364	Ohio Pippin	m	o c	y	m sa	g	Sept., Jan.	d	h	O.
365	Okabena	l	o	y r s	sa	vg	Dec.	d	h	Minn.

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastern Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	Remarks.
312	—	—	—	—	—	—	—	—	—	An Ulster County seedling not known elsewhere.
313	*	*				*	*	*	*	Choicely good. Adapted to fancy market.
314	—	—	—	—	—	—	—	—	—	Less desirable than standard kinds of its season.
315	—	—	—	—	—	—	—	—	—	Appears to be identical with Canada Reinette.
316	—	—	—	—	—	—	—	—	—	Not valuable enough to retain.
317	*	*	—	—	*	*	*	*	*	Worthy of planting for home or market, where it succeeds.
318	—	—	—	—	—	—	—	—	—	No longer propagated.
319	—	—	—	—	—	—	—	—	—	Does not succeed as far north as New York.
320	—	—	+	—	—	—	—	—	—	Worthy of testing in New York only when hardiness is a prime requisite.
321	—	—	—	—	—	—	—	—	—	Of Esopus *Spitzenburg* type but inferior to that variety.
322	*	*	—	—	*	*	*	—	*	A hardy, productive tree. Long keeper of fair quality. Slow in bearing and overbears.
323	—	—	—	—	—	—	—	—	—	Without value.
324	—	—	—	—	—	—	—	—	—	Does not excel standard varieties of its season.
325										Almost identical with Yellow Bellflower.
326	—	—	—	—	—	—	—	—	—	A Dutchess County apple unknown elsewhere.
327	*	*	—	*	*	*	*	*	*	Choicely good for the home orchard.
328	—	—	—	—	—	—	—	—	—	Suitable only for exhibition purposes.
329	—	—	—	—	—	—	—	—	—	Unknown outside of Chenango County.
330	—	—	—	—	—	—	—	—	—	Newtown group. Less valuable than other varieties of its season.
331	—	—	—	—	—	—	—	—	—	Valuable in the South only.
332	+	+	+	+	+	+	+	+	+	Worthy of testing particularly in elevated and northern portions of New York.
333										Unknown outside of Orange County.
334	—	—	—	—	—	—	—	—	—	Attractive but excelled by standard sorts.
335	—	—	+	—	—	—	—	—	—	Appears to be worthy of testing in northern part of the State.
336	—	—	—	—	—	—	—	—	—	It has failed to win favorable recognition in New York. Poor keeper.
337	—	—	—	—	—	—	—	—	—	Not a promising variety for New York.
338	—	—	—	—	—	—	—	—	—	A long keeper but does not rank high in quality. Southern.
339	—	—	—	—	—	—	—	—	—	Doubtful whether this variety will develop marketable size in New York.
340	—	—	—	—	—	—	—	—	—	Good cropper, uncertain keeper, variable in size.
341	—	—	—	—	—	—	—	—	—	Unsatisfactory in this region.
342	—	—	—	—	—	—	—	—	—	A good keeper, good cropper, moderately attractive. Seldom planted.
343	—	—	—	—	—	—	—	—	—	Without special value.
344	*	*				*	*	*	*	Tree characters poor. Appearance and quality of the best.
345	—	—	—	—	—	—	—	—	—	Of little value.
346	—	—	—	—	—	—	—	—	—	Nearly obsolete.
347	—	—	—	—	—	—	—	—	—	Similar to Yellow Bellflower. Surpassed by other sorts of its season.
348	—	—	—	—	—	—	—	—	—	Has given place to better sorts.
349	—	—	—	—	—	—	—	—	—	A late keeping sweet apple. Unattractive.
350	—	—	—	—	—	—	—	—	—	Not well tested here. Probably not valuable.
351	—	—	—	—	—	—	—	—	—	An old variety, now nearly obsolete in this State.
352										Of Yellow Bellflower group. Not recommended for general planting.
353	—	—	—	—	—	—	—	—	—	Not a good commercial sort. Excellent in quality.
354	—	—	—	—	—	—	—	—	—	Not superior to standard sorts of its season.
355	—	—	—	—	—	—	—	—	—	Not adapted to northern regions.
356	—	*	—	**	**	**	**	*	*	Tardy bearer. Vigorous. Highest quality. Succeeds only in certain localities.
357	—	—	*	—	—	—	—	—	—	Hardiness alone commends it.
358	—	—	+	—	—	—	—	—	—	Similar to Rhode Island *Greening*, hardier, not so good in quality.
359										Popular in Michigan. Unknown in New York.
360	—	—	—	—	—	—	—	—	—	Similar to Yellow Bellflower.
361	—	—	+	—	—	—	—	—	—	Blue Pearmain group. Adapted to cold climates.
362	—	—	—	—	—	—	—	—	—	Not now grown in New York.
363	—	—	—	—	—	—	—	—	—	Tree characters poor; of doubtful value.
364										Possibly worthy of attention in New York.
365	—	—	—	—	—	—	—	—	—	Nothing to recommend it for New York.

No.	Variety.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
366	Oldenburg........	m—l	r o	g y r s	sa	g—vg	Aug., Sept.	k	m	Rus.
367	Olive.............	s	r c	y r s	m sa	f—g	Nov., Feb.	k	h	N. C.
368	Oliver............	l—m	r o	g y r s	sa	g	Dec., Mar.	k	m	Ark.
369	Olympia..........	See description of Baldwin.								
370	Ontario...........	l	r o c	g y r s	b sa	g—vg	Nov., Mar.	d k	m	Can.
371	Opalescent........	l—vl	r c	y d r	m sa	g—vg	Nov., Feb.	d	m	O.?
372	Orange...........	Several varieties under this name, all worthless in New York.								
373	Orange Pippin....	At least two varieties of this name. Neither of value in New York.								
374	Orange Sweet.....	Several varieties under this name. Worthless in New York.								
375	Ornament.........	m	r c	y r s	m sa	g	Oct., Feb.	d	h	Eu.
376	Ortley............	l—m	ob c	w y bl	sa	vg	Oct., Feb.	d k	lm	N. J.?
377	Ostrakoff.........	m	r	y	b sa	f—g	Nov., Dec.	k	h	Rus.
378	Palmer...........	m—l	r	g y	b sa	g	Dec., Feb.	k	h	N. Z.
379	Palouse...........	l	ob c	y r s	sa	vg	Oct., Dec.	d	m	Wash.
380	Paragon..........	m	r c	y g r s	m sa	g—vg	Jan., May	d k	m	Tenn.
381	Park Spice........	m—l	r c	y r s	m sa	vg	Dec., Mar.	d	h	N. Y.
382	Parlin............	m—l	r o c	y r s	m sa	g	Oct., Feb.	d	h	Me.
383	Parry White......	m	r	y w	sa	g	Aug., Sept.	d	h	Pa.?
384	Parson...........	l	r c	y r	s	g—vg	Nov., Feb.	d	m	Mass.
385	Patten...........	m—l	o	g y	sa	g	Oct., Jan.	k	m	Ia.
386	Pawpaw..........	l	r ob c	y r s	sa	g—vg	Dec., June	d	m	Mich.
387	Payne............	m	r c	g y r s	m sa	g—vg	Jan., June	d	lm	Mo.
388	Peach............	m	o c	y bl	b sa	g—vg	Dec., May	d	h	Unk.
389	Peach (Montreal).	l	r ob c	y w bl	sa	g	Sept.	d k	h	Unk.
390	Peach Pond.......	m—s	o c	y r s	s	vg	Sept., Nov.	d	h	N. Y.
391	Pearsall..........	l	r	y r s	s	g	Nov., Jan.	k	h	N. Y.
392	Pease............	l—m	r	y g r s	sa	g—vg	Oct., Jan.	d	lm	Conn.
393	Peasgood Nonsuch	l	r o	y r s	sa	g	Sept., Oct.	k	h	Eng.
394	Peck *Pleasant*....	m—l	r o c	y bl	sa	vg—b	Nov., Feb.	d k	h	R. I.?
395	Pennock..........	l	r	g y r s	m sa	f—g	Dec., Apr.	k	m	Pa.?
396	Perry Redstreak..	m	o	y r s	m sa	g—vg	Oct.	d	h	N. Y.
397	Perry Russet......	m—l	o c	y ru	sa	g	Dec., Feb.	d k	h	R. I.?
398	Peter............	m	r o	y r s	m sa	g—vg	Sept., Oct.	d k	m	Minn.
399	Pewaukee.........	m—l	r o	y g r s	sa	f—g	Nov., Apr.	k	m	Wis.
400	Pickard Reserve..	l	o	g y bl	sa	vg	Nov., Feb.	d	h	Ind.
401	Pifer.............	m	o	g y r s	m sa	f	Jan., July	k	h	Pa.
402	Pine Stump.......	m	r	y r	sa	g	Nov., Feb.	k	m	N. C.
403	Plumb Cider......	m	r c	y r s	b sa	g	Oct., Jan.	k	m	O.?
404	Pomme Grise......	s	o r	y ru	sa	vg—b	Dec., Feb.	d	h	Can.?
405	Pomona..........	m—vl	o c	g y r s	sa	g—vg	Sept., Oct.	k	h	Eng.
406	Porter...........	s—l	ob c	y bl	sa	g—vg	Sept., Nov.	d k	h	Mass.
407	Pound Sweet.....	This name has been appled to several varieties of large sweet apples.								
408	Pratt Sweet......	l	r c	y r s	s	vg	Dec., Mar.	d	h	N. Y.
409	Priestly..........	l—m	r	g y r s	m sa	g	Dec., Apr.	c d k	h	Pa.
410	Primate..........	m—l	r c	y g	sa	vg—b	Aug., Sept.	d	h	N. Y.
411	Prince Albert.....	l	r c	y g r s	b sa	g	Nov., Feb.	k	m	Eu.
412	Prolific Sweeting..	m	r o	w y	s	g	Sept., Oct.	d	h	Rus.
413	Pryor............	m—l	r o	g y r s	sa	vg—b	Dec., Mar.	d k	m	Va.?
414	Pumpkin Russet..	l	o	g y ru	s	g	Sept., Oct.	k	h	N.Eng.
415	Pumpkin Sweet...	l—vl	r c	g y	s	g	Oct., Jan.	k	m	Conn.
416	(1) Quince (of Cole).	l—vl	o c	y	b sa	g—vg	July, Sept.	k	lm	Me.
417	(11) Quince (of Coxe).........	l	o	y	sa	g—vg	Nov.	k	lm	N. Y.
418	Ralls............	m	r o c	y r s	sa	vg	Dec., May	d k	lm	Va.?
419	Rambo...........	m	r o	g y r s	m sa	g—vg	Nov., Dec.	d	h	Unk.
420	Ramsdell Sweet...	l—m	ob c	y r s	vs	g—vg	Oct., Feb.	d k	h	Conn.?
421	Raspberry........	s	ob	r	sa	vg	July, Aug.	d	h	Rus.

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastern Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	REMARKS.
366	*	*	**	**	*	*	**	**	*	Hardy, vigorous, productive, cosmopolitan. Largely planted.
367	—	—	—	—	—	—	—	—	—	Unworthy of consideration by New York fruit growers.
368										As yet not sufficiently tested in New York.
369	+	+	—	+	+	+	+	+	+	A western type of Baldwin. Worthy of testing.
370	—	—	+	+	+	+	+	—	—	Similar to Northern Spy; hardier. Inferior in color and quality. Worthy of trial in Northern New York.
371										Not well tested in New York. Worthy of further test.
372										
373										
374										
375	—	—	—	—	—	—	—	—	—	Surpassed by other dessert apples of its season.
376	—	—	—	—	—	—	—	—	—	Yellow Bellflower group. Of good quality, but skin tender and susceptible to scab.
377	—	—	—	—	—	—	—	—	—	Of no value.
378										Not well tested in New York.
379	+	+			+	+	+	+	+	Supposed to be a seedling of Tompkins King. Worth testing.
380	—	—	—	—	—	—	—	—	—	A southern variety not well tested in New York.
381	—	—	—	—	—	—	—	—	—	Probably obsolete.
382										Not tested sufficiently to determine its value.
383	+	+				+	+	+	+	Resembles Early Harvest. Later. Worthy of trial.
384										Not tested sufficiently to determine its value.
385	—	—	+	—	—	—	—	—	—	Seedling of Oldenburg. Worth trying in the North.
386	—	—	—	—	—	—	—	—	—	Not recommended for planting in this State.
387	—	—	—	—	—	—	—	—	—	Probably not well suited to this State.
388	—	—	—	—	—	—	—	—	—	Not recommended for general planting. May be valuable locally.
389	—	—	—	—	—	—	—	—	—	Cannot displace Oldenburg which is the same in season.
390	—	—	—	—	—	—	—	—	—	Long known but has failed to establish itself.
391	—	—	—	—	—	—	—	—	—	A Queens County seedling; apparently obsolete.
392	+	+	—	—	+	+	+	+	+	Worthy of attention for home use and local market.
393	—	—	—	—	—	—	—	—	—	Scarcely tested; of doubtful value.
394	—	—	—	—	—	—	—	—	—	Shy bearer, subject to diseases. Fruit beautiful and excellent in quality.
395	—	—	—	—	—	—	—	—	—	Not regarded with favor as a commercial variety. Subject to "Baldwin spot."
396	—	—	—	—	—	—	—	—	—	Has not acquired a valuable reputation.
397	—	—	—	—	—	—	—	—	—	Excelled by other russets of its season.
398	—	—	—	—	—	—	—	—	—	Resembles Wealthy and does not surpass it.
399	—	—	*	—	—	—	—	—	—	Desirable only when hardiness is a prime requisite.
400										Not sufficiently tested in New York to determine its value.
401	—	—	—	—	—	—	—	—	—	Not recommended for planting in New York.
402	—	—	—	—	—	—	—	—	—	Not adapted to New York conditions. Southern.
403	—	—	—	—	—	—	—	—	—	Should give place to better sorts.
404		*	*	*	*	*	*	*	*	A small russet of high quality. Not profitable commercially.
405	—	—	—	—	—	—	—	—	—	An English sort, of little value in America.
406	*	*				*	*	*	*	Has many merits for home use and local market.
407										
408	—	—	—	—	—	—	—	—	—	An old variety now practically obsolete.
409	—	—	—	—	—	—	—	—	—	Surpassed by standard varieties of its season.
410	*	*				*	*	*	*	Tree characters poor. Valuable for dessert and local market.
411										Requires furher testing.
412	—	—	+	—	—	—	—	—	—	Worthy of trial in Northern New York.
413	—	—	—	—	—	—	—	—	—	Not well adapted to this region. Southern.
414	—	—	—	—	—	—	—	—	—	Should give place to others of better qualities.
415	*	*			*	**	**	**	*	Valued for home and market purposes.
416	—	—	—	—	—	—	—	—	—	Supplanted by better sorts.
417	—	—	—	—	—	—	—	—	—	Obsolete.
418	—	—	—	—	—	—	—	—	—	Seldom reaches marketable size in New York. Blossoms very late.
419	—	—	—	—	—	—	—	—	—	Tender tree; productive to a fault; excellent quality.
420	—	—	—	—	—	—	—	—	—	Without commercial value in New York.
421	—	—	—	—	—	—	—	—	—	Worthless except as a substitute for Red June where that sort winter kills.

No.	Variety.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
422	Red and Green Sweet	l—vl	ob c	y r s	s	f—g	Aug., Sept.	k	lm	Unk.
423	Red Astrachan	m—l	r	y r s	b sa	g—vg	Aug., Sept.	d k	m	Eu.
424	Red Canada	m	r c	y r s	m sa	g—b	Nov., Mar.	d k	m	Unk.
425	Red Hook	l—vl	r c	y r s	sa	g	Aug., Sept.	k	m	N. Y.
426	Red June	s—m	r	y r	b sa	g—vg	Aug., Oct.	d k	m	N. C.
427	Red Russet	A bud sport of Baldwin differing only in having a russet skin.								
428	Redstreak	s	ob	y r s	sa	g	Dec., Apr.	c k	h	Eng.
429	Red Transparent	m	r	y r	sa	g—vg	Aug.	d k	h	Rus.
430	Red Wine	m	r o	w r	sa	g	Aug., Sept.	k	h	Eu.
431	Reed	m	r	y w r s	sa	g	Nov.	k	h	N. Y.
432	Reinette Pippin	m—l	o	w y	sa	g	Oct., Feb.	d k	m	Fr.
433	Repka	m—s	r o c	y w	m sa	g	Aug., Sept.	k	h	Rus.
434	Repka Malenka	m—s	r c	y r s	m sa	g	Jan., Apr.	k	h	Rus.
435	Rhode Island *Greening*	l	r o	y g	sa	vg	Oct., Mar.	d k	m	R. I.?
436	Ribston	m—l	r	y r s	sa	vg	Oct., Dec.	d k	m	Eng.
437	Richard Graft	m	r o	y r s	sa	vg	Sept.	d	h	N. Y.
438	Ridge	l—m	r o b c	y	m sa	g	Feb., May	k	lm	Pa.?
439	Rock Pippin	m	r o	y g bl	sa	g	Feb., June	k	m	Unk.
440	Rolfe	m—l	r	y	b sa	g	Oct., Dec.	k	h	Me.
441	Romanite	s	r c	y r	sa	g	Mar., July	c d k	h	Unk.
442	Roman Stem	s	r	w y	sa	vg	Oct., Dec.	d	h	N. J.
443	Rome	l	r	g y r s	m sa	g	Nov., Apr.	k	m	O.
444	Romna	m—l	o c	g y b l	b sa	f—g	Sept., Jan.	k	h	Rus.
445	Ronk	m	r	r	sa	g	Oct., Feb.	d	h	Ind.
446	Roseau	m—l	o	g r	sa	g	Dec., Feb.	k	h	Unk.
447	Rose Red	m	o	w r s	sa	vg	Sept., Nov.	d	h	N. Y.?
448	Roxbury	l—m	o	y r u	sa	g—vg	Dec., May	d k	m	Mass.
449	Russian Baldwin	m	r o	y r s	m sa	g	Jan., May	k	h	Rus.
450	Rutledge	m	r	y r s	m sa	f—g	Jan., May	k	m	Tex.
451	Safstaholms	m—l	ob	y r s	m sa	g	Oct., Dec.	d	h	S'den.
452	Sailee Russet	m	o c	g r u	sa	g	Dec.	d	h	N. Y.
453	Sailly Autumn	m	r c	g y	sa	g	Sept.	k	h	N. Y.
454	St. Lawrence	l—m	o	g r s	m sa	g—vg	Sept., Oct.	d	h	Am.
455	St. Peter	s	r	g y r s	m sa	f	Aug.	k	h	Rus.
456	Salisbury	m—l	r	y	sa	g—vg	?	d k	h	N. Y.
457	Salome	m	r o c	y r s	sa	g—vg	Nov., Mar.	d k	m	Ill.
458	Sandy Glass	l—m	r o	g y bl	b sa	f—g	Sept., Nov.	k	h	Rus.
459	Savewell	m	r o	w y	sa	g	Feb., Mar.	k	h	N. Y.
460	Saxton	m	r o	y r s	sa	g vg	Sept.	d	h	Mass.?
461	Scarlet Cranberry	m	r	y r s	m sa	f—g	Feb., May	k	m	Va.
462	Scarlet Pippin	m	r	y r s	m sa	vg	Oct., Dec.	d k	h	Can.
463	Schodack	m	r o	y g r	b sa	f—g	Feb., June	k	h	N. Y.?
464	Schoonmaker	l	r o	g y bl	b sa	vg	Jan., Mar.	d k	h	Unk.
465	Schuyler Sweet	l	r	y	s	g—vg	Sept., Oct.	d	h	N. Y.
466	Scollop Gilliflower	m—l	r c	y r s	m sa	g	Nov., Feb.	k	h	Unk.
467	Scott	m	r o c	g y r s	b sa	g	Dec., Mar.	k	m	Vt.
468	Scott Best	m—l	r o	y r s	sa	g—vg	Nov., Dec.	d	h	N. Y.
469	Scribner	m	r c	y r s	sa	vg	Dec., Feb.	d	h	N. Y.
470	Seneca Favorite	l	r ob c	y	sa	vg	Nov., Jan.	d	h	N. Y.
471	Shackleford	m—l	r ov	g y r s	m sa	f—g	Nov., Apr.	d	m	Mo.
472	(I) Shannon	l	o	w y bl	sa	g—vg	Nov., Apr.	d k	m	Ark.
473	(II) Shannon	l—m	?	y	?	g	Nov., Apr.	d k	m	O.
474	Sharp	m	r o	y bl	m sa	vg	Sept., Oct.	d	h	Md.?
475	Sheddan	l—m	r	g y bl	m sa	g—vg	Jan., May	d	m	Tenn.
476	Sheriff	m—s	r o	y r s	m sa	g	Dec., Feb.	k	h	Pa.
477	Sherman	m	o	g y	s	g—vg	Nov., Jan.	d	h	N. Y.
478	Shiawassee	m—l	o c	y r s	sa	g—vg	Oct., Jan.	d	h	Mich.
479	Shirley	m—s	r c	y r s	m sa	f—g	Dec., May	k	m	Texas.
480	Sine-qua-non	m	r c	g y	m sa	g	Aug.	d	h	N. Y.
481	Skank	l	r c	y r s	m sa	g—vg	Oct., Feb.	d	h	Unk.
482	Sleight	A fac-simile of Lady except it is larger and ripens earlier.								Not known

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastern Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	REMARKS.
422	—	—	—	—	—	—	—	—	—	Better sorts are taking its place.
423	*	*	*	*	*	*	*	*	*	Succeeds under many conditions. Home and local markets.
424	—	*	*	*	*	**	**	*	*	Worthy of more extensive planting.
425		*								Grown only in the vicinity of Red Hook, N. Y.
426	—	—	—	—	—	—	—	—	—	Better adapted to the South and West. Small, scabby, imperfect in New York.
427										Considered less valuable than Baldwin.
428	—	—	—	—	—	—	—	—	—	An old cider variety now obsolete in New York.
429	—	—	—	—	—	—	—	—	—	Without value where Primate can be grown.
430										Untested in New York. Probably worthless.
431	—	—	—	—	—	—	—	—	—	Not worth testing.
432	—	—	—	—	—	—	—	—	—	Excelled by Rhode Island *Greening*.
433	—	—	—	—	—	—	—	—	—	Much inferior to Primate with which it competes.
434	—	—	—	—	—	—	—	—	—	Fruit too small to be valuable.
435	*	**	—	*	**	**	**	**	**	The standard green apple of New York. Second in commercial importance.
436	—	—	—	—	—	—	—	—	—	Belongs with Hubbardston which greatly excels it.
437										But little known outside of the Hudson Valley.
438	—	—	—	—	—	—	—	—	—	Excelled by others of its season.
439		*								One of the latest keepers of its class.
440	—	—	+	+	+	—	—	—	—	Tree very hardy. Otherwise without merit.
441	—	—	—	—	—	—	—	—	—	Not grown nor recommended for this State.
442	—	—	—	—	—	—	—	—	—	Superseded by better sorts.
443	*	*	—	—	*	*	*	*	*	Promising but not sufficiently tested.
444	—	—	—	—	—	—	—	—	—	Not worthy of attention.
445										Not well tested but probably worthless.
446										Identity not certain.
447	—	—	—	—	—	—	—	—	—	Discarded.
448	*	*	—	*	*	**	**	**	**	A leading commercial variety. Standard of its class.
449			+							May be valuable in Northern New York.
450	—	—	+	—	—	—	—	—	—	Of doubtful value. Very hardy.
451	—	—	—	—	—	—	—	—	—	Of very doubtful value.
452	—	—	—	—	—	—	—	—	—	Inferior to Roxbury.
453	—	—	—	—	—	—	—	—	—	Discarded.
454	—	—	*	—	—	—	—	—	—	It cannot be recommended except in Northern regions.
455	—	—	—	—	—	—	—	—	—	Not valuable.
456	—	—	—	—	—	—	—	—	—	Known only in the vicinity of Cortland. Value doubtful.
457	—	—	—	—	—	—	—	—	—	Excelled by standard sorts.
458	—	—	—	—	—	—	—	—	—	Worthless.
459	—	—	—	—	—	—	—	—	—	Not known outside of Westchester County.
460										Not grown in New York.
461	—	—	—	—	—	—	—	—	—	Southern. Does not mature here.
462	—	—	+	+	+	+	+	—	—	Worth testing where Fameuse succeeds.
463	—	—	—	—	—	—	—	—	—	Valuable only as a remarkably late keeper.
464	—	—	—	—	—	—	—	—	—	Nearly obsolete.
465	—	—	—	—	—	—	—	—	—	Probably lost to cultivation.
466	—	—	—	—	—	—	—	—	—	Obsolete.
467	—	—	**	—	—	—	—	—	—	Valuable in elevated and Northern regions.
468	—	—	—	—	—	—	—	—	—	Has no recognized value.
469	—	—	—	—	—	—	—	—	—	Probably obsolete.
470						*				Possibly of value for the home orchard.
471	—	—	—	—	—	—	—	—	—	Ben Davis group, but less desirable.
472	—	—	—	—	—	—	—	—	—	Resembles Ohio Pippin. Lacking in productiveness.
473										Not tested in this State.
474	—	—	—	—	—	—	—	—	—	Resembles Maiden Blush but it is not equal to that variety.
475										Possibly worthy of further testing.
476										Very hardy. Of no consequence otherwise.
477	—	—	—	—	—	—	—	—	—	Not grown outside the place of its origin.
478	—	—	—	—	—	—	—	—	—	Excelled by McIntosh which it resembles.
479	—	—	—	—	—	—	—	—	—	Ben Davis group but inferior to that sort.
480	—	—	—	—	—	—	—	—	—	Supplanted by better sorts.
481						+	+			Because of its high quality should not be allowed to pass out of cultivation.
482										outside of Dutchess County.

No.	Variety.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
483	Slingerland	m—l	r	y r	sa	g—vg	Dec., Feb.	d	h	N. Y.
484	Smith Cider	m—l	r o c	g y r s	sa	g	Nov., Mar.	c k	h	Pa.
485	Smokehouse	m—l	r o	g y r s	m sa	g	Oct., Mar.	d k	h	Pa.
486	Somerset (N. Y.)	m—s	r c	w y	sa	vg—b	Sept., Oct.	d	h	N. Y.?
487	Sops of Wine	m—l	r	g y r	m sa	g	Aug., Oct.	k	h	Eng.
488	Sour Bough	m	r c	y	b sa	g	Sept.	k	h	N. Y.
489	Spectator	m	r o b	y r	sa	f—g	Sept.	k	h	N. Y.
490	Spring Pippin	m	r	g y	sa	vg	Dec., May	k	h	N. Y.
491	Stanard	l	o c	g y r s	b sa	g—vg	Oct., Mar.	k	h	N. Y.
492	Stark	l—m	r c	y r s	m sa	f—g	Jan., June	k	m	O.?
493	Starkey	m—l	o	y r s	sa	vg	Oct., Jan.	d	m	Me.
494	Starr	vl—l	o	y g	sa	vg	Aug., Sept.	d	h	N. J.
495	Stayman Winesap	m—l	r c	y r s	sa	g—vg	Dec., May	d	m	Kan.
496	Sterling	l	r	y r	m sa	vg	Dec., Apr.	d	h	Mass.
497	Stillman Early	s	r c	y	sa	g	July, Aug.	k	h	N. Y.
498	Stone	l	r	y d r s	m sa	g—vg	Nov., Feb.	d k	m	Vt.?
499	Stowe	m—l	?	g y b l	sa	g	Dec., Mar.	k	h	Me.
500	Streaked Pippin	l	r o b	g y r s	sa	g—vg	Nov., Mar.	d k	l m	N. Y.
501	Striped Gilliflower	l—vl	r ob c	y w r s	b sa	f—g	Sept.	k	h	Unk.
502	Stroat	m—l	r	y g	b sa	g—vg	Sept., Nov.	d	h	N. Y.?
503	Strode Birmingham	m	r c	y	sa	g—vg	Sept., Nov.	d	m	Pa.
504	Stuart Golden	m	r o	y b l	m sa	vg	Dec., May	d	h	O.
505	Stump	m—s	r c	w y r s	sa	vg	Sept., Oct.	d	l m	N. Y.
506	Stymus	m	o	y r s	m sa	vg	Oct., Nov.	d	h	N. Y.
507	Suffolk Beauty	m	r o	y w	sa	g	Aug., Sept.	k	h	Unk.
508	Summer Bellflower	m—l	r ob c	y	sa	g	Aug., Sept.	k	h	N. Y.
509	Summer Pearmain	m	ob c	g y r	m sa	b	Aug., Sept.	d	h	Am.
510	Summer Queen	m—l	r c	y r s	sa	g—vg	Aug., Sept.	k	h	Unk.
511	Summer Rambo	l—vl	o	y r s	m sa	g	Sept., Nov.	k	m	Fr.
512	Summer Redstreak	m	r o c	y r s	b sa	g	Sept.	k	h	N. Y.
513	Summer Rose	s—m	r	y r s	m sa	g—vg	July, Aug.	d k	h	N. J.
514	Summer Spitzenburg	m	r c	w r s	sa	g—vg	Aug., Sept.	d	h	N. Y.
515	Summer Sweet	m	o	y	s	g—vg	Sept.	k	h	Conn.
516	Sutton	m	r	y r s	m sa	g—vg	Nov., Mar.	d k	m	Mass.
517	Swaar	l—m	r o	g y	m sa	vg—b	Nov., Apr.	d	h	N. Y.
518	Swazie	s	r o c	y ru	m sa	vg—b	Dec., Mar.	d	h	Can.
519	Sweet and Sour	m—l	o	y g	sa	f—g	?	?	?	Unk.
520	Sweet Bough	l—m	r c	g y	s	g—vg	Aug., Sept.	d k	l m	Am.
521	Sweet Fall Pippin	l	o	g y	s	g	Oct., Nov.	d k	h	N. Y.?
522	Sweet Greening	m—l	r o	y g	s	g—vg	Dec., Apr.	k	m	Mass.?
523	Sweet King	m	r c	y r s	s	g—vg	Oct., Mar.	d	h	N. Y.
524	Sweet Russet	m	o	y ru	s	g—vg	Nov., Mar.	d	h	Unk.
525	Sweet Russet	s	r	y ru	s	vg	Sept.	d	h	Unk.
526	Sweet Winesap	m—l	r c	w y r s	s	g—vg	Nov., Apr.	d k	m	Pa.
527	Swenker	m—l	r o c	y r s	m sa	f	Nov., Mar.	k	h	Pa.?
528	Switzer	m	r o	w y r	m sa	g	Aug., Oct.	d	h	Rus.
529	Sylvester	m—s	r o	w bl	b sa	vg	Sept., Oct.	k	h	N. Y.
530	Tart Bough	Two varieties under this name both of which are worthless.								
531	Tetofsky	m—s	r o	g y r s	sa	f—g	July, Aug.	k	m	Rus.
532	Tewksbury	s—m	r c	y bl	b sa	g	Jan., May	k	h	N. J.
533	Texas	m	r o c	y r c	m sa	g	Jan., May	k	m	Unk.
534	Thaler	Almost identical with Yellow Transparent which excels it in tree characters.								
535	Thompson	m	r c	w y r s	sa	f—g	Oct., Dec.	k	h	Ia.
536	Tinmouth	m—l	r o	g y	m sa	g	Oct., Dec.	k	h	Vt.
537	Titovka	l	r ob	g y r s	sa	g—vg	Aug., Sept.	k	h	Rus.
538	Titus Pippin	l—m	ob c	g y	sa	g—vg	Nov., Mar.	d k	h	N. Y.
539	Tobias	m	o	y	sa	f—g	Nov., Apr.	k	h	Vt.

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastern Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	REMARKS.
483	—	—	—	—	—	—	—	—	—	Has not gained recognition.
484	—	—	—	—	—	—	—	—	—	Unsatisfactory and unprofitable in New York.
485	—	—	—	—	—	—	—	—	—	Its cultivation is not being extended in New York.
486	—	—	—	—	—	—	—	—	—	Without merit.
487	—	—	—	—	—	—	—	—	—	Superseded by better varieties.
488	—	—	—	—	—	—	—	—	—	Unprofitable for any purpose.
489	—	—	—	—	—	—	—	—	—	Without value.
490	—	—	—	—	—	—	—	—	—	Unproductive and unprofitable.
491	—	—	—	—	—	—	—	—	—	Has not won favor in New York.
492	*	*			*	*	*	*	*	Considered valuable in some sections of New York.
493	—	—	+	+	+	—	—	—	—	Appears to be worthy of testing for the North.
494										Worthy of testing where a fruit of this type is desired.
495	—	—	—	—	—	—	—	—	—	Not adapted to New York conditions.
496	—	—	—	—	—	—	—	—	—	Apparently obsolete.
497	—	—	—	—	—	—	—	—	—	Discarded.
498	—	—	**	*	—	—	—	—	—	Blue Pearmain group. Valuable in Northern New York.
499										A Maine seedling unknown in New York.
500	*	*								Has many good qualities for local market.
501	—	—	—	—	—	—	—	—	—	Obsolete.
502	—	—	—	—	—	—	—	—	—	Passed from cultivation.
503	—	—	—	—	—	—	—	—	—	Surpassed by standard sorts.
504	—	—	—	—	—	—	—	—	—	Not recommended for commercial planting in this State.
505	*	*		*	*	*	*	*	*	Desirable for home use and for local market.
506	—	—	—	—	—	—	—	—	—	Now practically unknown in New York.
507	—	—	—	—	—	—	—	—	—	Lost to cultivation.
508	—	—	—	—	—	—	—	—	—	Dropped by the American Pomological Society.
509	*	*				*	*	*	*	Of value only as an amateur's fruit.
510	—	—	—	—	—	—	—	—	—	It has failed to establish itself.
511										An old sort, but possibly worthy of further testing.
512	—	—	—	—	—	—	—	—	—	Little known in New York.
513	—	—	—	—	—	—	—	—	—	Becoming obsolete.
514	—	—	—	—	—	—	—	—	—	Esteemed by some for home use.
515	—	—	—	—	—	—	—	—	—	Discarded.
516	*	**		+	+	*	*	*	+	Regarded as one of the most promising of the newer varieties.
517	*	*	—	—	*	*	*	—	—	One of the best for the amateur. Requires deep, rich, sandy loam. Shy bearer in places.
518	—	—	—	—	—	—	—	—	—	Similar to but inferior to Pomme Grise. Ranks high for dessert. Unproductive and too small for commercial use.
519	—	—	—	—	—	—	—	—	—	Worthless except as a curiosity.
520	**	**	—	—	—	**	**	**	*	A universal favorite for the home orchard and local market.
521	—	—	—	—	—	—	—	—	—	Gradually going out of cultivation.
522	—	—	—	—	—	—	—	—	—	Esteemed for home use. Seldom planted.
523	—	—	—	—	—	—	—	—	—	Not cultivated outside of Nassau County.
524	—	—	—	—	—	—	—	—	—	Several known by this name. Not grown in New York at the present time.
525	—	—	—	—	—	—	—	—	—	Possesses little value. Several under this name.
526	*	**	—	*	**	**	**	*	**	Attractive, excellent quality; reliable cropper; overbears; good keeper.
527	—	—	—	—	—	—	—	—	—	Does not excel standard sorts for any purpose.
528	—	—	—	—	—	—	—	—	—	Resembles the Fameuse, but inferior.
529	—	—	—	—	—	—	—	—	—	Without value.
530										
531	—	—	—	—	—	—	—	—	—	Surpassed by other sorts of its season.
532	—	—	—	—	—	—	—	—	—	Valued chiefly as a long keeper. Not recommended for New York fruit-growers.
533	—	—	—	—	—	—	—	—	—	Not recommended for planting in New York.
534										
535	—	—	—	—	—	—	—	—	—	Not worth planting in this State.
536	—	—	—	—	—	—	—	—	—	Does not appear desirable.
537	—	—	+	+	+	—	—	—	—	Perhaps worthy of testing in the North.
538	*	*								Yellow Bellflower group. Good tree characters. Fruit attractive and well flavored.
539	—	—	—	—	—	—	—	—	—	Not worthy the attention of fruit-growers except for hardiness.

No.	Variety.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
540	Tobias Black	m—l	r o	y g r s	m sa	f—g	Nov., Apr.	k	h	Vt.
541	Tobias Pippin	m	o c	y	m sa	g	Oct., Feb.	d k	h	Vt.?
542	Tolman *Sweet*	m	r	y	s	g—vg	Nov., Jan.	d k	h	Mass.
543	Tompkins King	l—vl	r	y r s	sa	vg—b	Oct., Jan.	d k	m	N. J.?
544	Tom Putt	l	r c	y r s	sa	f—g	Nov.,	k	m	Eng.
545	Tufts	l	r	y g r	m sa	f—g	Oct., Jan.	d	h	Mass.
546	Twenty Ounce	vl	r	g y r s	sa	g	Sept., Dec.	k	m	Unk.
547	Twenty Ounce Pippin	l—vl	r o	g y r s	sa	f—g	Oct., Feb.	k	m	Unk.
548	Tyre Beauty	m	r o	y r s	b sa	g	Sept.	k	m	N. Y.
549	Utter	l—m	r o	w y r s	m sa	g	Oct., Dec.	k	h	Wis.
550	Vandevere	m	r	y r s	m sa	g—vg	Oct., Jan.	k	h	Del.
551	Vandevere Pippin	l	o c	y r s	b sa	g	Sept., Nov.	k	m	Unk.
552	Vanhoy	m	r o	y g r s	m sa	f	Jan., May	k	h	N. C.
553	Victoria	m—l	r c	y r s	s	g—vg	Oct., Jan.	d k	h	N. Y.?
554	Victuals and Drink	l	o b	y g	s	vg	Oct., Jan.	d	h	N. J.
555	Vineuse Rouge	m—l	r o c	g y	sa	g—vg	Aug.	k	h	Rus.
556	Virginia Greening	m	o	g	m sa	f—g	Feb., June	k	h	Unk.
557	Wabash Red	l—m	r o	y r s	m sa	g	Dec., May	d	m	Ind.?
558	Wagener	m—l	r o	y r s	sa	vg—b	Oct., Feb.	d k	m	N. Y.
559	Walbridge	m	r c	w y r s	m sa	f—g	Nov., Feb.	k	m	Ill.?
560	Walker Beauty	m—l	r c	y bl	b sa	g	Nov., Apr.	k	h	Pa.?
561	Wallace Howard	l—m	r	y r s	m sa	g	Nov., Mar.	d	h	Ga.
262	Wandering Spy	l—m	r o	y r	sa	g	Jan., Apr.	k	m	Ark.
563	Washington Royal	m	r o	g y bl	m sa	g—vg	Oct., Mar.	d	h	Mass.
564	Washingt'n Strawberry	l	r c	g y r s	sa	g—vg	Oct., Dec.	d	h	N. Y.
565	Water	m	r ob c	g y bl	m sa	g	Oct.. Dec.	d	h	Pa.
566	Watwood	m	o	w y bl	sa	g	Dec., May	k	h	Ky.
567	Wealthy	l—m	r c	y r s	sa	g—vg	Oct., Jan.	d k	m	Minn.
568	Wells	l	r	w g r s	sa	vg	Nov., Mar.	d	m	Md.?
569	Western Beauty	For description see Grosh.								
570	Westfield *Seek-No-Further*	m	r c	y r s	m sa	vg—b	Oct., Feb.	d	m	Conn.
571	White Astrachan	m	r o	y w	b sa	g	Aug.	k	h	Rus.
572	White Juneating	s	r o	y	sa	g—vg	Aug.	d	h	Eng.
573	White Pearmain	m	r o	g y	m sa	vg—b	Dec., Mar.	d k	m	Unk.
574	White Pippin	m—l	r o	g y	sa	g—vg	Nov., May	d k	m	Unk.
575	White Spanish Reinette	vl	r o	y g	sa	vg	Oct., Jan.	d k	h	Eu.
576	Williams	m	r ob c	y r s	m sa	g	Aug., Sept.	d	h	Mass.
577	Willis Sweet	l	r	y r	s	vg	Aug., Sept.	d k	m	N. Y.
578	Willow	l—m	r c	y g r s	sa	f—g	Jan., May	k	m	Unk.
579	Willsboro	m	r c	y r s	sa	?	Dec., Feb.	?	h	N. Y.
580	Windsor	m	r c	y g r	m sa	g—vg	Dec., Apr.	d	h	Wis.
581	Wine Rubets	m—s	r	g bl	m sa	l—g	Aug.	k	h	Rus.
582	Winesap	s	r c	y r s	sa	g—vg	Jan., Apr.	d k	m	Unk.
583	Winter Banana	l	r ob c	w y bl	m sa	g—vg	Nov., Jan.	d k	l m	Ind.
584	Winter Pearmain	Several different varieties known under this name.								
585	Winter St. Lawrence	m—l	r	g y r s	sa	g	Nov., Jan.	d	h	Eng.
586	Winter Sweet Paradise	l	r o	g bl	s	vg	Nov., Mar.	d	h	Pa.
587	Winthrop Greening	l	o	y g	sa	g	Sept.	k	h	Me.
588	Wismer	m—l	r	y r s	m sa	g—vg	Jan., Apr.	d	m	Can.
589	Wolf River	vl	r o c	y r s	sa	f—g	Sept., Dec.	k	m	Wis.
590	Workaroe	m—l	r	y r s	m sa	g	Sept.	k	h	Rus.
591	Yellow Bellflower	s—vl	r ob c	w y	b sa	g	Dec., Apr.	k	l m	N. J.
592	Yellow Calville	m	o c	y	sa	f—g	Aug.	k	h	Rus.

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastern Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	REMARKS.
540	—	—	—	—	—	—	—	—	—	Hardy but not equal to standard varieties.
541	—	—	—	—	—	—	—	—	—	Hardy but not worthy of general planting.
542	*	*	**	**	*	*	*	*	*	Hardy, vigorous, early bearer, reliable cropper. Varies in keeping qualities.
543	*	*	—	—	*	**	**	*	**	Were the tree hardier, healthier, longer lived and more productive, it would be more commonly grown.
544	—	—	—	—	—	—	—	—	—	Tested and found unworthy.
545	—	—	—	—	—	—	—	—	—	Resembles the Baldwin; is less desirable.
546	*	**	—	—	—	**	**	*	*	One of the best of the fall varieties for home or market. (See Collamer).
547	—	—	—	—	—	—	—	—	—	Often confused with Twenty Ounce. Attractive but of poor quality.
548	—	—	—	—	—	—	—	—	—	Probably worthless.
549	—	—	—	—	—	—	—	—	—	Without value in New York.
550	—	—	—	—	—	—	—	—	—	Passing out of cultivation.
551	—	—	—	—	—	—	—	—	—	No longer listed by nurserymen.
552	—	—	—	—	—	—	—	—	—	Not desirable in any respect. Southern.
553	+	+		+	+	+	+	+	+	Worthy of trial where an apple of this type is desired.
554	—	—	—	—	—	—	—	—	—	An old variety, never popular in New York.
555	—	—	—	—	—	—	—	—	—	Scarcely worth testing.
556	—	—	—	—	—	—	—	—	—	Valued in the South as a late keeper. Not grown in New York.
557	+	+			+	+	+	+	+	Tree qualities good. Attractive, high quality, late keeper. Promising.
558	*	*	—	—	*	*	*	*	*	Early bearer; heavy cropper; short lived. Attractive and high quality.
559	—	—	—	—	—	—	—	—	—	Of comparatively little value in New York.
560		—	—	—	—	—	—	—	—	Unproductive and scarcely desirable.
561	—	—	—	—	—	—	—	—	—	Southern. Not adapted to New York.
562	—	—	—	—	—	—	—	—	—	Not well tested in New York. Unpromising.
563	—	—	—	—	—	—	—	—	—	Not recommended for commercial orchards.
564	—	—	—	—	—	—	—	—	—	Has failed to establish itself in the commercial orchards of New York.
565	—	—	—	—	—	—	—	—	—	Dropped by the American Pomological Society.
566	—	—	—	—	—	—	—	—	—	Inferior to standard varieties of its season.
567	*	*	**	**	*	*	**	**	*	Tree and fruit characters good. Its cultivation increasing. Runs small on old trees.
568	—	—	—	—	—	—	—	—	—	Not tested in New York. Unpromising.
569										
570	*	*	—	*	*	*	*	*	*	Tree qualities good. Uncertain in adaptability. A favorite dessert apple.
571	—	—	—	—	—	—	—	—	—	Discarded by American Pomological Society.
572	—	—	—	—	—	—	—	—	—	Has nothing to recommend it.
573	—	—	—	—	—	—	—	—	—	Not recommended for planting in this State.
574	—	—	—	—	—	—	—	—	—	Tree qualities good. Surpassed by standard sorts.
575	—	—	—	—	—	—	—	—	—	Supplanted by better sorts. The parent of many valuable varieties.
576	—	*	—	—	—	—	—	—	—	Has some points of merit for commercial planting.
577	—	—	—	—	—	—	—	—	—	Seldom planted.
578	—	—	—	—	—	—	—	—	—	Southern. Surpassed by others of its season.
579	—	—	—	—	—	—	—	—	—	Value unknown. Probably obsolete.
580	—	—	+	—	—	—	—	—	—	Very hardy. Promising for rigorous climates.
581	—	—	—	—	—	—	—	—	—	Not recommended for New York.
582	—	—	—	—	—	—	—	—	—	Both tree qualities and fruit poor in New York.
583	+	+		+	+	+	+	+	+	Promising for home and local market in New York.
584										
585	—	—	—	—	—	—	—	—	—	Not known in New York.
586	—	—	—	—	—	—	—	—	—	But little known in New York.
587	—	—	—	—	—	—	—	—	—	Dropped from cultivation.
588										Its value for this State is not known.
589	—	+	+	+	+	+	+	+	+	Of Alexander type. Worth testing.
590	—	—	—	—	—	—	—	—	—	Tested and found undesirable.
591	*	*	—	—	*	*	*	*	*	Poor cropper. Valuable in some districts. Bruises easily. Scabs considerably.
592	—	—	—	—	—	—	—	—	—	Much inferior to standard sorts.

No.	Variety.	Size.	Form.	Color.	Flavor.	Quality.	Season.	Use.	Market.	Origin.
593	Yellow Forest....	s—m	r o	g y bl	m sa	g	Jan., June	d	h	La.
594	Yellow Transparent..........	m	r c	w y	sa	g—vg	July, Aug.	d k	l m	Rus.
595	Yopp............	m—l	o c	w y bl	sa	f—g	Oct., Nov.	k	h	Ga.
596	York............	Golden Pippin and Fall Pippin often pass under this name.								
597	York............	m	r c	y	sa	g—vg	Oct., Nov.	k	h	Mass.
598	York Imperial....	m—l	r o	y r s	m sa	g—vg	Jan., Mar.	d k	m	Pa.
599	Zurdel...........	It is worthy of mention only for the purpose of stating that it has no value								
	CRABAPPLES.									
600	Bailey Crimson...	m—l	r	y r	sa	g		k	h	N. Y.
601	Brier............	l	r c	y r s	s	g	Sept., Oct.	d	h	Wis.
602	Cherry...........	s	o	y r s	m sa	g	Aug., Oct.	k	h	Unk.
603	Coral............	m	r o b	y b l	m sa	g	Oct., Feb.	d	h	Ill.
604	Currant..........	s	o	y r s	sa	f—p	Oct., Nov.	k	h	Unk.
605	Dartmouth.......	m—l	o	y r	m sa	g	Aug.	k	h	N. H.
606	Excelsior........	vl	r ov	y r	sa	g—vg	Sept.	d k	m	Minn.
607	Florence.........	m	o	y w r	b sa	g	Aug., Sept.	k	m	Minn.
608	Gibb............	l	r o	y b l	b sa	g	Aug.	k	h	Wis.
609	Hyslop..........	l—m	r ov	y r	sa	g	Sept., Oct.	k	m	Unk.
610	Large Red Siberian...........	m	r	y r s	sa	g	Sept., Oct.	k	h	Unk.
611	Large Yellow Siberian.........	l	r	y b l	sa	g	Sept., Oct.	k	h	Unk.
612	Marengo.........	l	r	y r	sa	g	Nov., Mar.	d k	h	Ill.
613	Martha..........	l	r o	y r	b sa	g—vg	Sept., Nov.	d k	m	Minn.
614	Minnesota........	l	r	y	sa	g	Sept., Oct.	k	h	Minn.
615	Montreal Beauty..	l	r o	y r	b sa	g	Sept., Oct.	k	h	Can.
616	Oblong..........	m	o c	y w r s.	sa	g		k	h	Unk.
617	Orange..........	m	r o	y	m sa	g	Sept., Nov.	k	h	Am.
618	Paul Imperial....	s—m	o	y r	b sa	g	Sept., Oct.	k	h	Eng.
619	Picta Striata.....	m—l	o	g y r s	sa	g	Oct., Dec.	k	h	Unk.
620	Quaker..........	m—l	r	y b l	sa	f	Oct.	k	h	Unk.
621	Queen Choice.....	m	r c	y r	sa	g	Oct.	k	h	Unk.
622	Red Siberian.....	s	r o	y r s	sa	g	Sept., Oct.	k	h	France
623	September........	m—l	r o	y r s	sa	g—vg	Sept.	d k	h	Minn.
624	Soulard..........	vl	o	y		p	Oct., Dec.			Ill.
625	Transcendent.....	m—l	r ob	y bl	sa	vg	Aug., Sept.	k	h	Unk.
626	Van Wyck........	l	r	w bl	s	g—vg	Aug., Sept.	d k	h	N. Y.
627	Whitney.........	l	r c	y r s	m sa	g—vg	Aug., Sept.	d k	h	Ill.
628	Yellow Siberian...	l—m	r o	y	sa	g	Sept.	k	h	Unk.

No.	Long Island.	Hudson Valley.	St. Lawrence and Champlain V'l'ys.	Mohawk Valley.	Eastean Plateau.	Central Lakes.	Ontario Shore.	Erie Shore.	Western Plateau.	REMARKS.
593	—	—	—	—	—	—	—	—	—	Of no value in New York except as a very late keeper.
594	**	**	*	*	*	*	*	*	*	One of the best extra early sorts for home and market.
595	—	—	—	—	—	—	—	—	—	Practically worthless.
596										There is also the following York.
597	—	—	—	—	—	—	—	—	—	Unknown in New York and probably worthless.
598	*	*	—	—	—	—	—	—	—	Reports adverse to its culture in New York except in southern portions.
599										for New York growers.
600	—	—	—	—	—	—	—	—	—	Passed from cultivation.
601	—	—	—	—	—	—	—	—	—	Has not gained recognition.
602	—	—	—	—	—	—	—	—	—	An old variety now little grown.
603										Probably of little value.
604	—	—	—	—	—	—	—	—	—	Very hardy but of no commercial value.
605	—	—	—	—	—	—	—	—	—	Lacks vigor. Excelled by other crabs.
606	*	*	*	*	*	*	*	*	*	One of the most desirable of its season. Dessert.
607	*	*	*	*	*	*	*	*	*	Desirable for commercial plantings because of both fruit and tree characters. Dessert.
608	*	*	*	*	*	*	*	*	*	Recommended for home use and possibly for market. Culinary.
609	*	*	*	*	*	*	*	*	*	Widely and deservedly cultivated for home and market. Culinary.
610	—	—	—	—	—	—	—	—	—	Better varieties are now preferred.
611	—	—	—	—	—	—	—	—	—	Superseded by larger varieties.
612	*	*	*	*	*	*	*	*	*	A good late keeping crab for home use. Culinary.
613	*	*	*	*	*	*	*	*	*	One of the best for culinary purposes.
614	—	—	—	—	—	—	—	—	—	Lacks productiveness at this Station.
615	—	—	—	—	—	—	—	—	—	Not grown in New York.
616	—	—	—	—	—	—	—	—	—	Fails in New York.
617	—	—	—	—	—	—	—	—	—	Not recommended for New York.
618	—	—	—	—	—	—	—	—	—	Does not find favor in America.
619	—	—	—	—	—	—	—	—	—	Tested and found unworthy at this Station.
620	—	—	—	—	—	—	—	—	—	Without special value.
621	—	—	—	—	—	—	—	—	—	Worthless.
622	*	*	*	*	*	*	*	*	*	A favorite for culinary use.
623	*	*	*	*	*	*	*	*	*	Suitable for kitchen or dessert.
624	—	—	—	—	—	—	—	—	—	Has no value in New York. A curiosity but of poor flavor.
625	*	*	*	*	*	*	*	*	*	Tree hardy, good grower, very productive. Very popular.
626	—	—	—	—	—	—	—	—	—	An old sort which has never become popular.
627	*	*	*	*	*	*	*	*	*	One of the most popular of the large crabs. Dessert and kitchen.
628	*	*	*	*	*	*	*	*	*	Valued for home use. Culinary.

VARIETIES OF STRAWBERRIES, WITH CULTURAL DIRECTIONS.*

O. M. TAYLOR.

SUMMARY.

Conditions of temperature and moisture in the vicinity of Geneva were favorable in 1905 for testing strawberries, although unfavorable in the western and eastern portions of the State.

Most of the varieties under test fruited in midseason. Fairfield and *Weston No.* 1 were the earliest desirable kinds, and among the latest were Cardinal, Mark Hanna, Mead, President, Ridgeway and Rough Rider.

Good size of fruit is essential. Some desirable kinds such as Ernie, Fairfield, Kansas and Senator Dunlap produce large fruit which decreases considerably in size as the season advances, while Cardinal, Joe, Mark Hanna, Marshall, Mead, President, Ridgeway, Rough Rider, *Thompson No.* 511, *Thompson No.* 700 and *Weston No.* 1 produce large fruit of desirable size to the close of the season.

Cardinal has many good qualities. Ernie may be valuable if not subject to leaf blight. Fairfield appears valuable only on account of earliness. Joe and Mead should be planted closer than other varieties. Mark Hanna is the most productive though low in quality. President is of largest size, an excellent show berry but deficient in quality. Glen Mary, Kansas, Marshall, Ridgeway, Rough Rider and Senator Dunlap are standard commercial kinds.

The rating in regard to yield is given in the description of the variety. Mark Hanna, the most productive kind, yielded at the rate of 12,400 quarts per acre, and the least productive kind was Midnight, yielding 1,114 quarts per acre. With some varieties such as Joe, Pan American and Commonwealth, the yield is largely deter-

*A reprint of Bulletin No. 276.

mined by distance of planting, as these varieties are usually very poor plant makers.

The cultural directions are not intended to be specific. They are rather suggestions along desirable lines. The details vary to suit the necessities of different sets of conditions.

INTRODUCTION.

In this bulletin are described many of the newer varieties of strawberries, together with a few standard kinds for comparison. These descriptions are followed by brief cultural directions which answer in a measure the many inquiries coming to this Station in regard to growing the crop.

The season of 1905 was marked by widely variable conditions in different parts of the State, both favorable and unfavorable to the best development of strawberries. Western New York was characterized by excessive rainfall, while the eastern portion of the State experienced a season of unusual drought. The conditions of temperature and rainfall were, however, fairly satisfactory in Central New York, especially in the vicinity of Geneva where the test was made.

The results herein noted must not be taken as absolute, indicating what might be expected under widely different conditions of environment. They simply point out the strong and weak features of certain varieties when tested under the soil conditions at this Station.

NOTES ON VARIETIES.

Season of ripening.— The terms early and late are but relative, and most of the varieties described in this bulletin ripened during midseason. None of those tested in this experiment were very early with the exceptions of Fairfield and *Weston No.* 1 which were nearly a week or more earlier than the other varieties. Possibly they may have some value on this account although both are lacking in flavor and quality. Among the later kinds were:

Cardinal,
Hunn,
Mark Hanna,
Mead,
President,
Ridgeway,
Rough Rider.

Size of fruit.—One of the requirements for a good commercial variety is that the fruit be of sufficient size to make a good appearance. The berries of some varieties uniformly run too small; with others the size at the first pickings is good but decreases rapidly as the season advances. A few, however, appear to hold their size well to the close of the season. This tendency varies with the environment, is influenced to some extent by congeniality of surroundings, and is modified by moisture conditions. The following varieties appeared to hold their size well to the end of the picking season:

Beidler,	President,
Cardinal,	Ridgeway,
Goldsborough,	Rough Rider,
Joe,	*Thompson No. 511,*
Mark Hanna,	*Thompson No. 700,*
Marshall,	*Weston No. 1.*
Mead,	

Desirable kinds.— Many of the varieties under test failed to make a good showing. It must be remembered, however, that varieties of all fruits, and especially strawberries, give widely varying results in different locations and under different conditions. The results here given were obtained from plants grown on a heavy, clay soil not well adapted to successful growing of this fruit. The following are those which appeared to be desirable either for home use or for commercial purposes:

Cardinal,	Mead,
Ernie,	President,
Fairfield,	Ridgeway,
Glen Mary,	Rough Rider,
Joe,	Senator Dunlap,
Kansas,	*Thompson, No. 511,*
Mark Hanna,	*Thompson, No. 700,*
Marshall,	*Weston No. 1.*

Plant makers.— One of the marked characteristics of varieties of strawberries is variation in the tendency to produce runners or to make new plants. Most of the varieties under test produced a moderate number. Some, however, made very few new plants, leaving the ground bare in places, while others were such prolific plant makers that the plants were badly crowded. In this experi-

ment all varieties were planted the same distance apart, three feet by two feet. In commercial work some of these varieties should be planted much closer, while others should have more room. The following is a list of varieties producing very few or very many plants:

VERY FEW PLANTS.	VERY MANY PLANTS.
Mark Hanna,	Challenge,
Ridgeway,	Commonwealth,
Senator Dunlap,	Goldsborough
Shenandoah,	Joe,
Stahelin.	Mead,
	Midnight,
	Pan American.

Productiveness.— Observations were made in the field at fruiting time in regard to apparent productiveness, and the fruit of each variety was weighed at each picking, the rate per acre being obtained from these figures. As yield is largely influenced by local conditions, the figures are omitted from this bulletin, the rating of productiveness being recorded in the description of each variety. The most productive kind, Mark Hanna, yielded at the rate of 12,400 quarts per acre. Among other productive varieties were Cardinal, Kansas, President, Ridgeway, Rough Rider, Senator Dunlap, Shenandoah and Stahelin.

Some varieties gave a very low yield. The least productive kind was Midnight, yielding 1,114 quarts per acre. Among other unproductive kinds were Commonwealth, Hunn, Joe, Pan American. Three of these, however, would have given a much higher yield had the plants been set closer, the individual plants in some cases being very productive.

DESCRIPTION OF VARIETIES.

In these descriptions the names in parentheses following the names of varieties indicate the source of the plants tested at the Station.

Beaver.—(John Mull, Dayton, O., and M. Crawford, Cuyahoga Falls, O.) Per. A chance seedling of unknown parentage, originated about 1901 by J. F. Beaver, Dayton, O., and introduced in 1904 by Mr. Crawford. Plants moderately numerous, moderately

vigorous, not very productive. Leaves medium to large, rather dark green; leaf stems medium length, thick. Fruit stems short, thick, usually double. Comes in bloom May 17. Calyx large, leafy, inclined to discolor, often slightly raised. Seeds raised. Fruit averages above medium in size, roundish conic, unattractive in color being dull pale scarlet, some portions of surface nearly white. Flesh quite pale, rather firm, rather acid, fair to good in flavor and quality. Does not pick easily. Foliage considerably injured by leaf blight. Does not succeed on the heavy soil at this Station.

Beidler.—(Mark T. Thompson, Rio Vista, Va.) Imp. Originated by Mr. Thompson who sent it to this Station for testing, as *No.* 602. Introduced by him under its present name in the Spring of 1905. Plants numerous, vigorous, very productive. Leaves large to above medium, dark green; leaf stems above medium to long, thick. Fruit stems long, stout, usually double. Comes in bloom May 20. Calyx large, leafy. Seeds raised or slightly sunken. Fruit large to very large wedge or sometimes coxcomb, often depressed along the center, sometimes with green or pale tips, usually light and dark scarlet. Flesh firm, juicy, rather acid, not high flavor or quality. Although the size is excellent to the close of the season, the general appearance is rather coarse, the fruit lacks attractiveness in shape, and the flavor and quality are not equal to the best varieties. The foliage is also severely attacked by leaf blight.

Cardinal.—(J. G. Streator, Garrettsville, O.) Imp. A self sown seedling originated by Mr. Streator in 1896. Nothing is certain concerning its parentage. The stock was sold to The Templin Co., Calla, O., who introduced the variety in the Spring of 1905. Plants rather numerous, vigorous, productive. Leaves large, dark green; leaf stems above medium to long, rather thick. Fruit stems long, stout, usually double. Comes in bloom May 23. Calyx large, leafy, usually not depressed, occasionally showing discolorations. Seeds raised. Fruit above medium to large, retaining its size till the close of the season, roundish conic, sometimes inclined to wedge, rather dark, dull or sometimes glossy scarlet. Flesh good color, firm, juicy, mildly acid, good in flavor and quality. Appears to be worthy of test on account of freedom from leaf blight, productiveness, excellent shape, fairly good color and desirable flavor and quality.

Challenge.—(Slaymaker & Son, Dover, Del.) Per. Introduced by M. Crawford, Cuyahoga Falls, O. Plants few, only moderately vigorous, not very productive. Leaves medium size, moderately dark green; leaf stems medium to below in length, rather slender. Fruit stems short, stout, usually double. Comes in bloom May 17. Calyx medium size, sometimes discolored. Fruit above medium to large, dropping considerably in size as the season advances, rather poor shape, varying from coxcomb or wedge to rather long roundish conic, rather unattractive dull scarlet. Flesh rather light color, moderately firm, juicy, lacking in flavor and quality. Of little value as fruited at this Station as the foliage is attacked by leaf blight, the berries are variable in size and shape, unattractive in color and inferior to standard varieties in flavor and quality. The variety would have given a better record in productiveness had the plants been set considerably closer, as but few runners were made during the season.

Climax.—(W. F. Allen, Salisbury, Md.) Per. Originated and introduced by H. W. Graham, Wetipquin, Md. Plants moderately numerous, rather vigorous, moderately productive to productive. Leaves medium to large, dark green; leaf stems medium to above in length, rather slender. Fruit stems medium length, stout, usually single. Comes in bloom May 18. Calyx medium to rather small, usually set in a very slight depression. Seeds slightly raised. Fruit above medium to large, dropping in size as the season advances, roundish conic to slightly wedge but blunt, surface rather smooth, dull, rather dark scarlet, not particularly attractive. Flesh good color, firm, juicy, agreeable mild acid, good in flavor and quality. This variety has desirable characteristics in shape, firmness, flavor and quality but is deficient in size in the later pickings.

Commonwealth.—(Slaymaker & Son, Dover, Del.) Per. Originated in 1902 by William H. Monroe, Commonwealth, Mass., and introduced by C. F. Pratt, Reading, Mass. Plants not numerous, only moderately vigorous, not very productive. Leaves medium to below in size, rather pale green; leaf stems short, rather slender. Fruit stems short, thick, usually single. Comes in bloom May 27. Calyx medium size, usually slightly depressed, often discolored. Seeds very numerous. Fruit variable in size, ranging from below medium to large, variable shape, coxcomb to irregular roundish

conic or slightly wedged, dark glossy scarlet. Flesh good color, firm, juicy, not high flavor or quality. Foliage somewhat injured by leaf blight. Does not appear promising at this Station on account of variable size and low flavor and quality. On account of habit of making but few runners, the plants should be set considerable closer than usual to secure a good yield.

Ernie.—(A. R. Weston & Co., Bridgman, Mich.) Per. Originated by Dr. S. Mandlin, Bridgman, Mich., in 1895. Introduced by A. R. Weston & Co. in 1903. Parentage unknown. Plants moderately numerous, vigorous, moderately productive. Leaves above medium to large, dark green; leaf stems long, moderately thick. Fruit stems rather short, moderately thick, usually double. Comes in bloom May 17. Calyx rather large, leafy, set in a slight hollow. Seeds raised. Fruit above medium to large, dropping in size as the season advances, roundish conic, slightly elongated, attractive, glossy, rather dark scarlet. Flesh good color, firm, aromatic, agreeable mild acid, good to very good in flavor and quality. Foliage considerably injured by leaf blight. Appears to be worthy of further testing.

Fairfield.—(M. Crawford, Cuyahoga Falls, O.) Per. Plants only moderately numerous, vigorous, moderately productive. Leaves medium size, light green; leaf stems rather long, rather slender. Fruit stems short to medium, stout, usually double. Comes in bloom May 15. Calyx rather large, recurved. Seeds numerous, moderately depressed. Fruit large at first pickings, dropping rapidly to below medium as the season advances, roundish conic, sometimes quite sharply pointed, large berries often with furrowed surface, attractive light scarlet. Flesh well colored, moderately firm to firm, rather acid, lacking somewhat in flavor and quality, ranking no more than fair. Picks easily. One of the earliest to ripen. Although undesirable in quality, it may have some value where earliness is the prime requisite.

Glen Mary.—(L. J. Farmer, Pulaski, N. Y.) Per. Originated by Mr. Jugham, West Chester, Pa. Introduced by W. F. Allen, Salisbury, Md. This standard variety was for some reason very unsatisfactory in 1905 and a complete description under such conditions would not do justice. Plants set in 1904 made a weak growth producing scarcely any runners, and the fruit in 1905, while good

in flavor and quality, was abnormal in color and shape. When well grown it is desirable on account of large size, attractive color and good flavor and quality.

Goldsborough.—(A. T. Goldsborough, Wesley Heights, Washington, D. C.) Imp. Originated by Mr. Goldsborough and introduced by him in 1903. It is a cross between a wild berry and the British Queen. Plants very few, rather vigorous, not very productive. Leaves large, rather light green; leaf stems long, stout. Fruit stems moderately long, thick, usually double. Comes in bloom May 19. Calyx large, leafy, rather pale green. Seeds rather large, slightly raised. Fruit above medium to large, retaining its size till close of season, blunt pointed, roundish conic to slightly wedge, rather unattractive pale or dull scarlet. Flesh good color, firm, agreeable mild acid, good in flavor and quality. Picks easily. Although this variety is very satisfactory in size, firmness, flavor and quality, the color is so unattractive that it is doubtful if it will prove popular as a commercial variety.

Hunn.—(From bed in Station grounds.) Imp. Originated at this Station during the winter of 1889–90. Plants moderately numerous, moderately vigorous, not very productive. Leaves medium size, dark green; leaf stems short, moderately thick. Fruit stems short, stout, usually single. Comes in bloom June 1. Calyx large, leafy, usually set in a slight depression. Fruit above medium to very large, blunt roundish conic to slightly wedge, very dark glossy scarlet. Flesh good color, firm, juicy, good to very good in flavor and quality. One of the latest varieties. This variety has been tested in many parts of the State but has never become very popular. On most soils it has proved unproductive and the foliage has been severely attacked by leaf blight. It does not retain its size well during the later pickings.

Joe.—(J. H. Black, Son & Co., Hightstown, N. J.) Per. Originated by Black, Son & Co., fruiting for the first time in 1893. Introduced by them in 1899. A seedling of Middlefield and Chairs was crossed with Sharpless, and one of the best seedlings obtained in this way was crossed with Gandy. The most promising of this cross was named Joe. Plants not numerous, vigorous, moderately productive. Leaves large, medium dark green; leaf stems long, thick, usually double. Comes in bloom May 24. Calyx medium to

rather large, rather leafy, usually not depressed. Seeds slightly raised. Fruit above medium to very large, retaining its size throughout the season, blunt, roundish conic or irregular wedge, surface often furrowed, attractive dark scarlet. Flesh good color, firm, agreeably acid, good flavor and quality. On account of making few runners should be planted closer than most varieties. Has many qualities that commend it, especially large size of fruit and freedom of plants from leaf blight.

Kansas.—(W. F. Allen, Salisbury, Md.) Imp. Originated by J. J. Whittman, Emporia, Kans., and introduced by Mr. Allen in the Spring of 1900. It is said to be a chance seeding of unknown parentage. Plants moderately numerous to numerous, moderately vigorous, not injured by leaf blight, productive. Leaves medium size, rather pale green; leaf stems medium length, rather slender. Fruit stems moderately long, thick, usually single. Comes in bloom May 23. Calyx large, leafy usually in a depression. Seeds slightly raised. Fruit averages above medium to medium in size, decreasing in size as the season advances, roundish conic to slightly wedge shape, rather blunt, tip often ending in a depression, surface often irregularly furrowed, attractive, rather moderately dark scarlet. Flesh good color, firm, juicy, mildly acid, good to very good in flavor and quality. Although this variety does not rank as a large berry, it has proved to be a desirable commercial sort in many places on account of productiveness, attractive color and good flavor and quality.

Mark Hanna.—(Mark T. Thompson, Rio Vista, Va.) Imp. A seedling of Bubach, originated by Mr. Thompson. Plants numerous, healthy, very productive. Leaves medium size, moderately dark green; leaf stems long, medium to rather thick. Fruit stems long, thick, usually double. Comes in bloom May 17. Calyx medium to below, usually reflexed, rather leafy, usually not depressed. Seeds numerous, sunken. Fruit large to very large, retaining good size till close of season, irregularly shaped, often coxcomb or wedge, sometimes roundish conic, surface often irregularly furrowed, rather attractive light scarlet, rather glossy. Flesh of fairly good color, moderately firm, juicy, agreeably tart, fair to good in flavor and quality. Although not of highest quality, it is by far the most productive variety fruited this season on the Station

grounds, and on account of the great yield, together with large size, it may have considerable value where quality is not the first requisite. The general appearance of some of the larger fruits is slightly coarse.

Marshall.—(From bed in Station grounds.) Per. Originated and introduced about 1892 by M. F. Ewell, Marshfield Hills, Mass. Plants moderately numerous, moderately vigorous to vigorous, moderately productive. Leaves rather large, rather dark green; leaf stems medium length, stout. Fruit stems medium length, stout, usually double. Comes in bloom May 15. Calyx medium size. Seeds moderately raised, rather large. Fruit very large to above medium, roundish conic to wedge, surface often irregularly furrowed, attractive dark glossy scarlet. Flesh well colored, firm, juicy, good to very good flavor and quality. Berries sometimes inclined to greenish tips. This is a standard commercial variety, considered very valuable in certain localities but does not succeed on all soils, ranking rather low in productiveness in many places.

Mead.—(J. H. Hale, South Glastonbury, Ct.) Per. Originated with O. E. Mead, Lunenburg, Mass., about ten years ago. Introduced to the trade by Mr. Hale in Spring of 1904. Plants only moderately numerous, moderately vigorous, productive. Leaves medium to above in size, dark green; leaf stems above medium length, moderately thick. Fruit stems short, thick, usually double. Comes in bloom May 24. Calyx medium to above in size, rather leafy. Seeds variable, raised or slightly depressed. Fruit above medium to large, blunt, roundish conic, surface smooth. Flesh good color, firm, mild acid, good in flavor and quality. On account of few runners should be planted closer than most varieties. Appears to be worthy of testing.

Midnight.—(J. H. Hale, South Glastonbury, Ct.) Per. Plants not numerous, lacking in vigor, not productive. Leaves below medium to medium in size, pale yellowish-green; leaf stems short, slender. Fruit stems short, moderately thick, usually single. Comes in bloom May 15. Calyx medium to large, sometimes discolored, not depressed. Seeds raised. Fruits variable, below medium to very large, roundish conic to wedge, irregular both in size and shape, rather unattractive light or dark scarlet. Flesh light

colored, firm, possibly good in flavor and quality. Not equal to standard varieties.

Pan American.—(Samuel Cooper, Delevan, N. Y.) Per. Originated in 1898 as a sport of the Bismark by bud variation, and introduced by Mr. Cooper in 1902. Plants producing very few runners, moderately vigorous; individual plants very productive. Leaves medium to below, rather dark green; leaf stems rather short, rather slender. Fruit stems short, stout, usually double. Comes in bloom May 15. Calyx small, rather deeply set. Seeds very numerous, raised. Fruit medium to above, blunt pointed, roundish conic, moderately attractive, rather dull or pale scarlet. Flesh, rather pale red, firm, slightly aromatic, no more than good in flavor and quality. Does not pick very easily. The chief characteristic of this variety is its habit of fruiting in the fall. When the first blossoms are removed until midsummer, the plants will fruit in late August through September and until checked by frosts in early October. May have some value where strawberries fruiting at this season are desired. It should be planted considerably closer than most varieties.

President.—(Slaymaker & Son, Dover, Del.) Imp. Originated about 1900 by M. R. Hunt of Lambertville, N. J. Plants moderately numerous, vigorous to very vigorous, productive. Leaves large, very dark green; leaf stems long, stout. Fruit stems long, stout, usually double. Comes in bloom May 24. Calyx rather large, leafy. Seeds slightly depressed. Fruit of largest size, roundish blunt conic, slightly furrowed, attractive bright scarlet. Flesh fair or rather light color, moderately juicy, very mild, fair to good in flavor and quality. Foliage somewhat injured by leaf blight. The largest and most attractive variety in the Station collection but somewhat deficient in flavor and quality. One of the most promising varieties where size and color are prime requisites.

Ridgeway.—(From bed in Station grounds.) Per. Originated and introduced some years ago by M. H. Ridgeway of Indiana. Plants numerous, vigorous, productive to very productive. Leaves medium to above in size, rather dark green; leaf stems medium to above in length, stout. Fruit stems short, stout, usually double. Comes in bloom May 17. Calyx large, leafy. Seeds very

slightly sunken. Fruit above medium to large, retaining size fairly well in later pickings, roundish conic to slightly wedge, blunt pointed, rather smooth surface, bright scarlet or pale scarlet, often glossy. Flesh usually good color, moderately firm, juicy, good flavor and quality. This variety has many characteristics which commend it highly for commercial purposes. It, however, is not quite as firm as some of the other standard varieties and the calyx detaches very readily in seasons of abundant moisture.

Rough Rider.—(L. J. Farmer, Pulaski, N. Y.) Per. Said to be a cross of Bubach and Gandy, originated in 1893 by Charles Learned, and introduced in 1900 by L. J. Farmer. Plants moderately numerous, moderately vigorous to vigorous, productive. Leaves medium size, medium dark green; leaf stems above medium length, rather slender. Fruit stems medium length, slender to rather thick, usually double. Comes in bloom May 18. Calyx, medium to below, rather leafy, often reflexed. Seeds depressed. Fruit large to above medium, retains good size during the season, somewhat wedge to roundish conic, rather dark, attractive scarlet. Flesh good color, firm, agreeably acid, good in flavor and quality. A desirable late berry on account of size, attractiveness and good characters of flesh.

Senator Dunlap.— (L. J. Farmer, Pulaski, N. Y.) Per. Originated by J. R. Reasoner, Urbana, Ill., and introduced by M. Crawford, Cuyahoga Falls, O., in 1899.* Parentage uncertain but possibly a seedling of Warfield. Plants very numerous, very vigorous, productive. Leaves medium to above in size, moderately dark green; leaf stems long, slender. Fruit stems long, moderately slender, usually single. Comes in bloom May 15. Calyx medium size, recurved, not sunken. Seeds medium or above in size, slightly sunken. Fruit medium to very large, does not retain its size till close of season, roundish conic or slightly elongated, often with tendency to slight neck, glossy, attractive light and dark scarlet. Flesh well colored, moderately firm to firm, rather mild, good flavor and quality. Picks easily. Inclined to produce too many plants. Although somewhat variable in size is desirable on account of attractiveness and good flavor and quality.

* Letter, Reasoner, April 10, 1900.

Shenandoah.— (W. A. Shook, McGaheysville, Va.) Per. Plants numerous, rather vigorous, productive. Leaves medium size, medium dark green; leaf stems medium length, moderately slender. Fruit stems long, rather slender, usually single. Comes in bloom May 15. Calyx large, leafy, usually not depressed. Seeds slightly sunken. Fruit above medium to large, dropping in size as the season advances, roundish conic to blunt wedge, light scarlet. Flesh fairly good color, moderately soft, good in flavor and quality. Variable in size and hardly firm enough for a desirable commercial variety.

Stahelin.— (M. Crawford Co., Cuyahoga Falls, O.) Imp. Plants numerous, vigorous, very productive. Leaves medium size, light green; leaf stems long, moderately slender. Fruit stems long, rather stocky, usually single. Comes in bloom May 15. Calyx rather small, often inserted in a hollow. Seeds numerous, somewhat raised. Fruit medium to nearly large, dropping rapidly in size as the season advances, oblate conic to roundish conic or wedge, attractive light scarlet. Flesh fairly good color, firm, rather acid, fair to good quality but not high flavor. Picks easily. The fruit is variable in size, the surface is often uneven as if improperly pollinated and the hull is frequently discolored. As it lacks in flavor and quality, it does not appear equal to standard varieties of its season.

Thompson No. 511.— (Mark T. Thompson, Rio Vista, Va.) Per. Plants very numerous, very vigorous, very productive. Leaves large to above medium, dark green; leaf stems long, moderately thick. Fruit stems long, moderately thick, usually double. Comes in bloom May 24. Calyx large, leafy, reflexed. Seeds raised. Fruit large, usually wedge, or semi-double, often deeply furrowed, sometimes rather long roundish conic, glossy, attractive moderately dark scarlet. Flesh fairly good color, firm, moderately juicy to juicy, mild, good in flavor and quality. Rather irregular in shape but holds its size well till close of season. Appears to be worthy of further test on account of attractive appearance and desirable flesh characters.

Thompson No. 700.— (Mark T. Thompson, Rio Vista, Va.) Per. Originated by Mr. Thompson. Plants very numerous, very vigorous, very productive. Leaves medium to above in size, dark

green; leaf stems long, slender. Fruit stems long, medium to rather slender, usually single. Comes in bloom May 15. Calyx medium to below, often unattractive brownish color. Seeds numerous, rather large, sunken, giving a somewhat coarse appearance. Fruit above medium to large, irregular wedge varying to roundish conic, light scarlet. Flesh good color, firm, juicy, agreeably acid, good in flavor and quality. More acid than Marshall. The berries pick easily and retain their size well in the later pickings. Appears to be worthy of testing on account of its productiveness and good flavor and quality, although in some pickings the fruit was not very attractive either in shape or color.

Weston No. 1.— (A. R. Weston, Bridgman, Mich.) Per. Plants numerous to very numerous, vigorous, productive. Leaves medium to large, pale green; leaf stems long, rather slender. Fruit stems long, slender, usually single. Comes in bloom May 15. Calyx medium, reflexed. Seeds rather small, slightly sunken. Fruit above medium to large, holding its size well throughout the season, roundish conic to irregular wedge, rather light scarlet. Flesh rather light at center, moderately soft, mild, fair to good in flavor and quality. Picks easily. A good sized early berry but lacks in flavor and quality.

STRAWBERRY — CULTURAL DIRECTIONS.

Soil.— The strawberry is cosmopolitan in adaptation to soils, some varieties thriving on nearly all kinds and over a wide range of territory. As a rule, however, the lighter loams are better adapted to most varieties than are the heavy clay soils.

Preparation of ground.— Sod soils should be avoided on account of danger of injury from the work of the larvae or grubs of the common May beetles which lay their eggs in sod ground. The soil may be plowed in fall or early spring after receiving a heavy application of stable manure, and should be made fine and mellow by thorough cultivation before setting the plants. It is usually an advantage to select ground upon which a hoed crop had been grown the preceding season in order to reduce the number of weeds in the strawberry bed.

Fertilizers.— The amount and kind of fertilizer to use depend largely upon the need of the soil in which the plants are to grow

and may be entirely different in some other locality or on a different soil. The ground may be in need of nitrogen, potash or phosphoric acid, or may lack humus, *i. e.*, decaying organic matter. Humus may be supplied by stable manure or by the plowing under of plants of various kinds, clover crops being especially desirable as they tend to supply nitrogen. If the plants do not make sufficient growth an application of nitrate of soda or of dried blood at the rate of from one hundred to two hundred pounds per acre may be beneficial. A lack of potash may be supplied by applications of wood ashes or of muriate of potash using the latter at the rate of about five hundred pounds per acre; and phosphoric acid may be supplied by applications of acid phosphate at the same rate. There are various other fertilizers that might be named. Attention is called to the desirability of making tests of different fertilizers leaving check rows to determine the actual need of the particular soil. Applications of fertilizers may be given during the first season's growth, and these should be made early or in midsummer rather than in late fall. Under some conditions an application the second Spring as growth starts may also be beneficial.

Selection of varieties.— As with other fruits there is a wide variation in the behavior of varieties under different conditions, and for commercial plantings only those varieties should be set extensively that have made a good record locally; newer varieties should be tested in a small way and their value definitely determined before setting them in the plantation.

Sex of plants.— Attention is also called to the sex of the plants. Rows of imperfect blooming kinds should alternate with perfect bloomers to secure pollinization of the imperfect blossoms. If only those varieties which are imperfect, *i. e.*, in which the blossoms contain no stamens in addition to the pistils, such as Cardinal, Kansas, President, etc., be planted the result is usually a failure and unless there are a sufficient number of blossoms nearby of perfect bloomers, such as Marshall, Ridgeway, Rough Rider, etc., the incomplete fertilization is indicated by an abundance of nubbins, berries with hard, greenish, undeveloped apex. The kind of pollen does not appear to influence the character of the fruit. For instance — the fruit of Kansas (imperfect) always seems the same in size, shape,

color and flavor no matter whether the pollen be supplied from Marshall, Fairfield or Joe, which differ widely.

Selection of plants.— The best plants are none too good and as a rule should be taken, not from old beds, but from young beds which have not yet fruited, discarding the weak or inferior ones. A system of selection intelligently followed for a series of years should result in an improved strain. If the so-called "pedigree" plants are superior to others it is because of intelligent, long continued selection.

Setting the plants.— The distance apart of the rows and of the plants in the row varies somewhat with the natural richness of the soil, and considerably with the ability of the varieties grown to make runners. Varieties producing the largest number of plants may be set as far apart as four by two and a half or three feet, while those producing but few plants may be set three feet by eighteen inches or even closer,— an average distance being three by two feet for most varieties. The plants are usually set in early Spring.

Summer treatment.— During the summer the ground should be kept cultivated and the plants hoed as occasion requires. The blossom clusters should be removed, and the earliest runners be encouraged to root as early as possible. Some fertilizer may be applied if necessary as indicated on page 411.

Winter treatment.— On the approach of winter the plants should be given protection against the freezing and the thawing of the ground. The best covering is one that is free from weed seeds, spreads evenly, is not blown off by heavy winds, and does not mat down too closely over the plants. It is only necessary to cover the plants out of sight — an inch or two deep being more desirable than three or four inches. Various materials may be used for this purpose such as marsh hay, course stable manure, straw, or rough refuse.

Spring and second summer treatment.— In early spring it may be necessary to shake up the covering to prevent the plants from smothering, and as growth begins some of the material should be removed from over the plants and placed between the rows. Generally no further treatment is necessary except to hand pull the larger weeds, but where these are troublesome it may sometimes be necessary to remove the litter and to give thorough cultivation,

replacing it before the berries ripen to keep the fruit clean and to retard evaporation.

It is usually not considered necessary to spray the foliage for leaf blight but where the disease is serious it may be kept in check by applications of bordeaux mixture; but such applications should not be made while the plants are in bloom nor so late that the bordeaux shows on the ripe fruit.

Usually only one crop is taken from a bed, resetting each year, but if the plants are vigorous and healthy and the ground comparatively free from weed seeds, they may be left for a second crop. The tops are usually cut and the entire surface burned over as soon as the plants have finished fruiting or the cut leaves and mulching are removed, the rows being narrowed down to strips about six inches wide. Further cultivation and fertilization will be as usual.

VARIETIES OF RASPBERRIES AND BLACKBERRIES, WITH CULTURAL DIRECTIONS.*

O. M. TAYLOR.

SUMMARY.

Only varieties which have been tested on the Station grounds during the past eight years are included in this bulletin.

Among red raspberries *Bradley No.* 1 and Brilliant have not been fully tested but appear to be of doubtful value. Cline is valuable only on account of earliness. The fruit is small and the plants unproductive. Cuthbert is still the most popular variety throughout the State. Herbert has made a good record and is worthy of testing. King and Royal Church are inclined to crumble. Loudon is desirable but is quite variable in growth of cane. Marlboro canes are rather dwarf but are very productive. Pomona lacks productiveness on some soils. Turner is an old variety, hardy and productive, but the fruit averages too small.

Purple raspberries are superior for canning. Their value for this purpose is not fully appreciated. Columbian and Shaffer are both desirable kinds. Haymaker is productive; has not been fully tested but appears hardly equal in size or quality to varieties already mentioned.

Black raspberry plantations should be frequently renewed on account of injury from anthracnose. Beyer is a new kind ripening its fruit on the current season's growth; requires further testing, as yet does not show many desirable characters. Black Diamond is variable, being worthless on some soils. Cumberland, Gregg, Mills and Onondaga produce fruit of excellent size and color. Eureka, Mohler and Palmer are among the most desirable early kinds. Ohio is not grown as extensively as formerly, and is used more for evaporating than for market purposes.

*A reprint of Bulletin No. 278.

The winter injury to blackberries has been severe during the past five years. Many kinds require winter protection. Agawam and Ancient Briton produce large crops of berries, medium to above in size. Chautauquà and Florence are new, and although rather promising, require further testing. Eldorado, Mersereau, and New Rochelle produce fruit large in size. Rathbun is somewhat tender. Snyder is the most cosmopolitan of all the varieties, and although the fruit is small the canes are hardy and very productive.

Cultural directions are not given in detail, as they must vary under the different conditions found on different farms. The most important topics are briefly discussed and suggestions are given in regard to some of the methods followed by successful growers.

INTRODUCTION.

It is eight years since a bulletin has been issued by this Station on raspberries or blackberries, although notes have been taken yearly in regard to the behavior of the many varieties growing in the Station plats. It appears desirable at the present time to publish this information in a condensed form to meet the numerous inquiries regarding these fruits. The following notes describe the varieties and indicate their behavior for a series of years under the conditions in which they have been grown at this Station.

A discussion of insects and diseases infesting raspberries and blackberries is not given in this bulletin as the subject is covered in Bulletin 170 of this Station. It is sufficient at this time to state that anthracnose is one of the most serious diseases of black raspberries and has wrought havoc in many plantations during the past five years. The best treatment appears to be to dig out and burn the infested canes; to frequently set out the new plantations in land that has not grown berries in some time; to select the healthiest stock available; and to give the best of care in order to secure a healthy, vigorous growth well ripened for the winter.

At fruiting time, observations were made in the field in regard to the productiveness of all varieties, and the exact yield was also recorded at each picking. As these figures vary from year to year in different localities, depending on amount of winter injury, insect and fungus troubles, rainfall at harvest time, character of the soil and the attention the plants have received, the figures have been

omitted and no attempt has been made to group the varieties in regard to yield. The record of productiveness, however, is given in the description of each variety.

Descriptions are given of many old varieties, together with those of more recent introduction. In the description of varieties, the source of the plants is usually given following the name of the variety. In many cases the plants have been secured from the originator or introducer in order to obtain stock true to name. The value of the variety is summed up with most sorts, in the closing sentence of the description.

It has been thought best to arrange the varieties, as far as possible, in their natural groups. So arranged, similar kinds can be better compared both as to characters and as to behavior in the field. In the main the varieties are grouped in accordance with Card's classification in his Bush Fruits.*

AMERICAN RED RASPBERRIES.

(*Rubus strigosus.*)

NOTES ON VARIETIES.

Hardiness.— Records have been made each spring in regard to the amount of winter injury. This varied considerably from year to year, depending upon the severity of the winter, and on the condition of the wood when it went into winter quarters, ranging in some cases from 0 to 75 per ct. In the following lists, those varieties not injured over 25 per ct. in any year, and with an average considerably below that number, have been marked as hardy or nearly so, and those injured over 25 per ct. as not hardy.

HARDY OR NEARLY HARDY.		NOT HARDY.
Bradley No. 1,	Miller,	Brilliant,
Carleton,	Olathe,	Great American.
Coutant No. 2,	Phoenix,	
Cuthbert,	Pomona,	
Eaton,	Royal Church,	
Gault,	Superb,	
Herbert	Superlative,	
Kenyon,	Thompson,	
Koch No. 1,	Turner,	
Loudon	Viking.	
Marlboro,		

* Published by The MacMillan Co., of New York.

Earliness.— The value of the time of ripening varies in different locations depending on the market, some growers finding the early varieties most profitable while others secure the greatest returns from late-fruiting kinds. While the relative time of ripening of varieties may not vary much from year to year, the dates of ripening for any one sort may be quite different depending on local conditions. No clear cut division can be made in regard to season of ripening; some varieties have a very long season of fruiting, while with other varieties the reverse is true. For several years Giant, Marlboro, and Pomona were among the first to produce ripe fruit while the following varieties were among the latest to produce good pickings:

Bradley No. 1,	English Giant,	Phoenix,
Coutant No. 2,	Herbert,	Royal Church.
Cuthbert,	Loudon,	

Desirable kinds.— Many of the varieties tested were found to be worthless in this locality. Some were too tender, or not productive; others produced fruit too small and too soft for shipment, or the color was unattractive, and the flavor and quality inferior. The following list, however, includes those varieties that have made the best showing, and under conditions at the Station are of value commercially and are worthy of testing elsewhere:

Cuthbert,	Loudon,	Pomona,
Herbert,	Marlboro,	Turner.*

DESCRIPTION OF VARIETIES.

Bradley No. 1.— (C. P. Bradley, South Bend, Ind.) A seedling found growing on the farm of Mr. Bradley about the year 1896. Received at this Station for testing in the fall of 1902, fruiting for the first time in 1904. Plants moderately vigorous to vigorous, healthy; appears to be hardy and productive. Fruit above medium to large, resembles Marlboro in shape but is much coarser in general appearance, rather attractive dark red, grains large, inclined to crumble, good in flavor and quality. Requires further testing to fully determine its value, but the large grains give it a coarse appearance, and it seems inclined to crumble.

*See description.

Brilliant.†—(Meyer & Son, Bridgeville, Del.) Received for testing at this Station in 1901. Plants not very vigorous, not an upright grower, canes rather slender, winter injury from 50 to 75 per ct. during the past three years. On account of this severe injury enough fruit has not been produced for a good description. Appears to be too tender for this locality unless protected during the winter.

Carleton.—(J. Craig, Ottawa, Can.) Received for testing at this Station about ten years ago. Plants moderately vigorous, hardy, productive. Fruit medium to below, light red, grains large, inclined to crumble, fair to good in flavor and quality. Not equal to standard varieties.

Coutant No. 2.—(S. L. Quinby, Marlboro, N. Y.) Plants vigorous to very vigorous, upright, winter injury from 0 to 15 per ct. during the past four years, not very productive. Fruit averages above medium to medium in size, light red, moderately firm, sometimes inclined to crumble, fair to good in flavor and quality. Although it holds its size fairly well in late pickings, it lacks somewhat in size and productiveness, and is not equal to standard varieties in flavor and quality.

Cuthbert: *Quinby Favorite.*—An old variety received from various sources for testing at this Station. A chance seedling found by Thos. Cuthbert in Southeastern New York in 1865. Plants vigorous, healthy, rather erect; foliage rather dark green; usually hardy, productive. Fruit large, slightly conical, attractive red, grains medium to below in size, moderately firm to firm, sweet, good to very good in flavor and quality. This is by far the most popular variety among red raspberries, and seems to be well adapted to many localities. Its season of ripening is not very early but the crop ripens quite evenly through a rather long season.

Eaton.—(A. Garretson, Pendleton, Ind.) Originated and introduced a few years ago by Mr. Garretson. Said to be a hybrid between the Shaffer and the Cuthbert. Plants moderately vigorous, nearly hardy, moderately productive. Fruit averages large, grains large, crumbles badly, moderately firm, fair quality. Although it keeps its size well in late pickings, it is not equal to standard varieties on account of habit of crumbling and low quality.

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†Species uncertain.

Gault.—(W. C. Gault, Ruggles, O.) A stray seedling found over ten years ago by Mr. Gault by the roadside near his home. Plants vigorous, nearly hardy, productive. Fruit medium size or below, rather dull red, grains medium in size, moderately firm, inclined to crumble, fair in flavor and quality. Inferior to standard kinds.

Golden Queen.—An old variety received from various sources for testing at this Station. A yellow raspberry supposed to be a seedling of the Cuthbert, and found on the grounds of Ezra Stokes, Camden, N. J., in 1883. Plants vigorous to very vigorous, canes light in color, nearly hardy, productive. Fruit averages above medium, attractive light yellow sometimes tinged with light pink, soft, juicy, resembles Cuthbert in shape, very good in flavor and quality. On account of its color and softness is not valuable commercially.

Great American.—(J. L. Childs, Floral Park, N. Y.) Received for testing in 1896. Plants not vigorous, dwarfish, winter injury from 10 to 50 per ct. during the past four years, moderately productive. Fruit medium to large, fairly good color, rather soft, often inclined to crumble, no more than fair to good in flavor and quality. As fruited here not equal to standard kinds.

Herbert.—(R. B. Whyte, Ottawa, Can.) A chance seedling found about fifteen years ago by Mr. Whyte, and sent out for testing by him as "Whyte No. 17." Received for testing at this Station in 1896. Plants moderately vigorous to rather vigorous, not so tall as Cuthbert, hardy or nearly so, very productive. Fruit above medium to very large, averaging slightly larger than Cuthbert, attractive red, moderately firm to nearly firm, averaging slightly softer than Cuthbert, juicy, good to very good in flavor and quality. This variety appears to be one of the most promising of the newer red raspberries, and is considered worthy of testing for commercial purposes.

Kenyon.— (O. A. Kenyon, McGregor, Ia.) Introduced by Mr. Kenyon who found it growing wild in 1885. Supposed to be a seedling of Shaffer. Plants vigorous, hardy, productive. Fruit medium to above, dark red color, moderately firm, inclined to crumble, fair in flavor and quality. Not equal to standard kinds.

Koch No. 1.— (C. H. Koch, Middlehope, N. Y.) Plants moderately vigorous to vigorous, moderate amount of winter injury, productive. Fruit medium to large, firm, grains large, somewhat inclined to crumble, good flavor and quality. Not equal to standard varieties.

Loudon.—(F. W. Loudon, Janesville, Wis.) Originated by Mr. Loudon, and is supposed to be a seedling of Turner crossed with Cuthbert. Introduced by Chas. A. Green, Rochester, N. Y. Plants only moderately vigorous, not very tall, stocky, usually hardy, productive to very productive. Fruit averages above medium to large, often slightly larger than Cuthbert, grains rather large, firm or nearly so, attractive red color, moderately sweet, good in flavor and quality. This is a standard commercial variety, which has made an excellent record in many places.

Marlboro.—An old variety received from various sources for testing at this Station. It is said to be a cross of a seedling and the Highland Hardy and originated by Mr. A. J. Caywood, Marlboro, N. Y. Plants only moderately vigorous, almost semi-dwarf, canes very stocky, usually hardy, productive. Fruit medium to large, attractive red, firm, sometimes inclined to crumble, fair to good in flavor and quality. A standard commercial variety in many localities.

Miller: *Miller Woodland.*—A rather old variety received from various sources for testing at this Station. A seedling found growing wild at Wilmington, Del. Plants rather weak and semi-dwarf, suckers freely, mature canes tinged with brown, usually hardy, only moderately productive. Fruit averages medium in size, rather light and dark red, surface of berry sometimes rough and uneven detracting from appearance, very firm, moderately juicy, sometimes inclined to crumble, fair in flavor and quality. Not equal to standard varieties.

Olathe.—(Stayman & Black, Leavenworth, Kan.) Originated by Mr. Stayman and is said to be a seedling of Reliance. A late berry which has been tested for a number of years at this Station. Plants vigorous, with rather slender canes, slightly tinged with red, usually rather hardy, productive. Fruit above medium to large, firm, juicy, attractive rather dark red, grains medium to below, sometimes inclined to crumble considerably, good flavor and quality.

Hardly equal to standard varieties, as the fruit too frequently is inclined to crumble.

Phœnix.—(L. J. Farmer, Pulaski, N. Y.) Received at this Station for testing in 1896. Plants vigorous or moderately so, canes rather slender, usually hardy, only moderately productive. Fruit variable in size ranging from below medium to large, firm, rather dark red, grains medium size, sometimes inclined to crumble, fair to good in flavor and quality. Hardly equal in size or quality to standard kinds.

Pomona.—(Wm. Parry, Parry, N. J.) Introduced by Mr. Parry about 1887. Plants moderately vigorous to vigorous, canes stocky, usually quite hardy, moderately productive to productive. Fruit large, attractive light red, firm, nearly sweet, fair to good in flavor and quality. In some places has proved unproductive.

Royal Church.—(Royal Church, Harrisonville, O.) A chance seedling originated by Mr. Church. It has been tested for a number of years at this Station. Plants vigorous, canes slightly tinged with reddish purple, foliage rather dark green, moderate amount of winter injury. Fruit above medium to large, variable in color from light to very dark red, grains above medium to large, inclined to crumble considerably, good in flavor and quality. Hardly equal to the best varieties.

Thompson: *Thompson's Early Prolific.*—(Cleveland Nursery Co., East Rockport, O.) Has been tested for a number of years at this Station. Plants vigorous, upright, canes tinged with red, rather slender, nearly hardy, not very productive. Fruit medium, moderately firm to rather firm, good red color, inclined to crumble, fair to good flavor and quality. Inferior to standard kinds.

Turner.—An old variety received from various sources for testing at this Station. Originated by J. B. Turner, Jacksonville, Ill. Plants vigorous, medium in height, upright, hardy, productive. Foliage rather dark green. Suckers freely. Fruit only medium size, bright attractive red color, juicy, moderately firm, good to very good in flavor and quality. Season of fruiting is earlier than that of Cuthbert. Although the fruit is inferior in size to Cuthbert, Marlboro or Loudon, it is a favorite in some places for home use and for local market where such varieties do not succeed.

Viking.—Plants of this variety were received in 1895 from the originator, Chas. H. Koch, Middlehope, N. Y. Bushes moderately vigorous, with moderate amount of winter injury, unproductive to moderately productive. Fruit averages medium in size, nearly round, attractive red color, good flavor and quality. Hardly equal to standard kinds.

EUROPEAN RED RASPBERRIES.

(*Rubus idæus.*)

DESCRIPTION OF VARIETIES.

Belle de Fontenay.—Plants from France, received for testing from the Department of Agriculture, Washington, D. C., in 1899. Bushes vigorous, apparently hardy, moderately productive. Fruit medium to large in size, dull red, moderately firm, grains rather large, rather acid, fair quality. Not equal to standard varieties.

Cline.— (G. W. Cline, Winona, Ont.) A chance seedling of unknown parentage found by Mr. Cline over twelve years ago. Plants moderately vigorous, medium in height, healthy, hardy, unproductive, very early. Fruit medium to below, grains medium to rather large, firm, rather sweet, rather dark red, fair to good flavor and quality. The chief value of this variety appears to be in its earliness. It will, however, probably never become of much value commercially as the fruit is small, and the plants are unproductive, the season being extremely short, most of the crop being secured in two or three pickings.

King.—(Cleveland Nursery Co., Rio Vista, Va.) An old variety which has fruited for several years at this Station. Plants moderately vigorous to vigorous, rather hardy, productive. Fruit medium to large, moderately firm, inclined to crumble, grains large, attractive bright red color, juicy, fair to good in flavor and quality. Not equal to Cuthbert or Loudon, although it has made a fairly good record in some places.

Merveille Rouge.—Plants from France, received for testing from the Department of Agriculture, Washington, D. C. Plants vigorous, hardy, rather productive. Fruit large to very large, rather dark red, soft, sweet, good in flavor and quality. Too soft for shipping any distance.

Naomi.—(Chas. Carpenter, Kelley Island, O.) Originated in the garden of Governor Wood, Cleveland, Ohio, and introduced by Mr. Carpenter. Plants moderately vigorous to vigorous, producing few suckers, foilage rather dark green, winter injury from 10 to 75 per ct. for the past five years. Fruit above medium to large, grains rather large, attractive red color, rather soft, nearly sweet when fully ripe, pleasant flavor, fair to good in quality. Inferior to standard varieties.

Orange: *Brinckle's Orange.*—An old yellow raspberry that has been received from various sources for testing. Plants not vigorous, dwarfish, slender, winter injury from 10 to 80 per ct. for the past four years, usually unproductive on account of winter injury. Fruit above medium to large, slightly lighter in color than Caroline, grains above medium size, very soft, good to very good in flavor and quality. One of the best in quality of the yellow raspberries but too soft for shipping, and requires winter protection in this locality.

Perpetuelle de Billard.—Plants from France, received from the Department of Agriculture, Washington, D. C., for testing. Plants moderately vigorous, hardy, moderately productive. Fruit large to very large, soft, attractive red color, good in flavor and quality. Undesirable.

Pride of Geneva.—(H. Loomis, Geneva, N. Y.) An old variety said to have been brought to this country by an English gardener many years ago. Disseminated by Steele Bros., Geneva, N. Y., under the present name. Plants moderately vigorous, hardy, moderately productive. Fruit medium size, grains coarse, moderately firm, slightly acid, quality fair. Inferior to standard varieties.

Pride of Kent.— (R. S. Edwards, Highland, Colo.) Said to have originated over fifteen years ago by Mr. Fallstaff, of Kent, England. Plants moderately vigorous to vigorous, canes rather large, stocky, winter injury varied from 0 to 75 per ct. for the past five years, only moderately productive. Fruit variable in size ranging from below medium to large, of good red color, moderately firm or rather soft, good in flavor and quality. Not equal to standard varieties and not firm enough for a good commercial kind.

4-Saisons.—Plants from France, received for testing from the Department of Agriculture, Washington, D. C. Plants moderately vigorous, hardy, not very productive. Fruit medium or below in size, firm, rather dark red, fair flavor and quality. Inferior to standard kinds.

Superlative.—(Ellwanger & Barry, Rochester, N. Y.) Plants dwarfish with rather slender canes, winter injury varied from 0 to 75 per ct. during the past six years, not very productive. Fruit above medium to very large, attractive red, rather soft, good to very good in flavor and quality. An old variety of good quality, but the plants are rather tender, unproductive and the fruit too soft for shipping any long distance.

Surpasse Falstoff.—Plants from France, received for testing from the Department of Agriculture, Washington, D. C. Bushes moderately vigorous, hardy, moderately productive. Fruit large, light red, rather soft, lacking in both flavor and quality. Appears to be undesirable.

Surpasse Merveille.— Plants from France, received from the Department of Agriculture, Washington, D. C., for testing. Bushes hardy, vigorous, productive. Fruit medium to above, moderately firm, good in flavor and quality. Fruit drops rapidly in size as the season advances, and does not appear to be equal to standard kinds.

Surprise D'Automne.—Plants from France, received for testing from the Department of Agriculture, Washington, D. C., in 1899. Bushes moderately vigorous, hardy, moderately productive. Berries medium to below in size, moderately firm, only moderately attractive yellowish color. Not equal to standard varieties in flavor or quality.

Talbot.—(M. J. Ellis, Norwood, Mass.) A seedling discovered in the garden of Mr. J. W. Talbot, Norwood, Mass., about 1888. Plants vigorous, healthy, usually hardy, moderately productive to productive. Fruit medium to large, attractive red color, rather soft, grains large, juicy, mildly acid, good in flavor and quality. Inferior to such standard kinds as Cuthbert, Marlboro or Loudon.

PURPLE RASPBERRIES.

(*Rubus neglectus.*)

Varieties of this type are intermediate in character between red raspberries and black raspberries. They are supposed to be hybrids between these two species. They show all gradations in habit between the two parent types, some being propagated by suckers, others by tips, and still others by either tips or suckers. The color of the fruit is usually a light or dark purple. Of the varieties described, only two, Columbian and Shaffer, at the present time appear to have any commercial value. Haymaker promises to be productive and firm but the fruit does not average as large as that of Columbian or Shaffer.

The purple raspberries are unexcelled for canning purposes, being superior in flavor and quality to the red raspberries, but the unattractive purplish color is a great drawback to their sale and in many markets they are sold only in limited quantities unless their real value is fully known.

DESCRIPTION OF VARIETIES.

Caroline.—An old variety received at this Station for testing from various sources. Originated over twenty-five years ago by S. P. Carpenter, New Rochelle, N. Y., and is supposed to be a seedling of the Orange crossed by a Golden Cap. Plants vigorous, numerous, upright, canes light colored, stocky, covered with very few prickles, foliage rather dark green, hardy, very productive. Fruit medium size, of orange-pink color deepening to salmon tinge when fully ripe, juicy, soft, very good in flavor and quality. One of the best light-colored raspberries. May be propagated either by suckers or by tips. The season of fruiting is somewhat longer than with most varieties. On account of color and softness, is not of much commercial value but ranks so high in flavor and quality that it is a universal favorite for home use where a berry of this type is desired.

Columbian.— (J. T. Thompson, Oneida, N. Y.) This variety was propagated and introduced by Mr. Thompson about twenty years ago. A seedling of the Cuthbert grown near a Gregg raspberry, and believed to be a hybrid between these two varieties.

Plants very vigorous, healthy, canes larger, more vigorous and slightly yellower than those of Shaffer, hardy or nearly so, very productive. Fruit above medium to very large, moderately juicy, firm, nearly sweet, slightly darker purple than Shaffer, good to very good in flavor and quality. The Columbian and Shaffer are two of the best purple varieties grown for commercial purposes, and in some places it has been claimed that they are identical. The two varieties have been grown side by side for a number of years on the Station grounds, and although they have many similar characteristics, they appear to be distinct both in the size and color of the canes and in the average size, color and firmness of the berries. The fruit of Columbian averages slightly smaller than that of Shaffer, is firmer, and hangs to the bushes better than does that variety. The principal objection to this class of fruit for commercial purposes is the unattractive color, although when canned it is superior to the red varieties both in flavor and in quality.

Haymaker.—(A. O. Haymaker, Earlville, O.) Originated and introduced by Mr. Haymaker a few years ago who found it growing on his farm. Received at this Station for testing in 1901. Plants moderately vigorous to vigorous, healthy, winter injury from 5 to 15 per ct. during the past four years, productive. Fruit medium to large, averaging smaller in size than Shaffer or Columbian, resembling a black raspberry in shape, color light and dark purple, presenting a rather unattractive appearance, firm, not equal to Columbian or Shaffer in flavor or quality. Requires further testing to fully determine its value, but up to the present time appears to be rather inferior to either Shaffer or Columbian.

Morrison Seedling.— (J. P. Morrison, Forestville, N. Y.) Sent to this Station for testing in 1896 by Mr. Morrison, the originator. Plants vigorous, nearly hardy, moderately productive. Fruit small to medium, irregular in size, grains large, rather soft, fair in flavor and quality. Decidedly inferior to Shaffer or Columbian.

Percy.—(J. Craig, Ottawa, Can.) Originated by William Saunders, London, Ont., as a hybrid between Gregg and Cuthbert. Plants moderately vigorous to vigorous, usually rather hardy, productive. Fruit medium to above, rather darker in color and softer than Shaffer, often inclined to crumble, not equal to Shaffer in

flavor or quality. Although earlier than Shaffer or Columbian, is not equal to those varieties for commercial purposes.

Redfield.—(J. Wragg & Son, Waukee, Ia.) Said to be a hybrid which was originated by Wragg & Son, from whom plants were received for testing in 1895. Plants moderately vigorous to vigorous, usually rather hardy, moderately productive. Fruit small to medium, dull unattractive purple, moderately firm, fair to good flavor and quality. Decidedly inferior to Columbian or Shaffer.

Sarah.—(J. Craig, Ottawa, Can.) A seedling of Shaffer originated by William Saunders, London, Ont. Received at this Station for testing in the Spring of 1896. Plants very vigorous, usually hardy, only moderately productive. Fruit medium or above, rather unattractive reddish purple, rather soft, fair to good in flavor and quality. Not equal to Columbian or Shaffer in productiveness, size, or quality.

Shaffer: *Shaffer's Colossal.*—An old variety received from various sources for testing at this Station. Originated by Geo. Shaffer, Scottsville, N. Y., about 1871, and introduced by Chas. A. Green, Rochester, N. Y. Plants slightly less vigorous and canes a little darker and smaller than Columbian, hardy or nearly so, productive but not quite so heavy a yielder as Columbian. Fruit averages slightly larger than that of Columbian, slightly softer, with a lighter purple tinge and slightly more acid in flavor, ranking good to very good in flavor and quality. This is one of the best of the purple raspberries, and is highly esteemed for canning.

Superb.—(J. T. Lovett & Co., Little Silver, N. J.) Originated with J. Churchman, Burlington, N. J., over thirty years ago. Plants semi-dwarf or only moderately vigorous, usually hardy, not very productive. Fruit medium to large, moderately firm, rather dark red, grains above medium, good in flavor and quality. Too variable in size and not productive enough for a good commercial sort.

Teletaugh.—(J. F. Street, West Middleton, Ind.) Originated with Mr. Street, who states that it is a hybrid produced by crossing Shaffer with Gregg. Plants moderately vigorous, moderate amount of winter injury, moderately productive. Fruit medium to below, grains large, moderately firm, rather unattractive dark

purple, often inclined to crumble, fair in flavor and quality. Not equal to Shaffer.

Wallace.—(T. G. Wallace, Atlantic, Ia.) Originated with Mr. Wallace. Received for testing in 1898. Plants moderately vigorous to vigorous, winter injury from 0 to 25 per ct. for three years, productive. Fruit below medium to above medium, rather unattractive dull reddish purple, only moderately firm, more acid than Columbian or Shaffer, fair flavor and quality. So far as tested at this Station is not equal to standard purple varieties.

BLACK RASPBERRIES.

(*Rubus occidentalis.*)

NOTES ON VARIETIES.

Hardiness.— During the past five years the winter injury to most of the varieties was not due so much to their lack of hardiness as it was to the weakened condition caused by the destructive work of the fungus disease, anthracnose, already referred to on page 416 For this reason lists are not given although the average rating in regard to winter injury is in most cases recorded in the description of each variety.

Earliness.— The season of black raspberries is considerably shorter than that of the red varieties, a larger percentage of the crop being usually secured at each picking. The following lists indicate the varieties which begin to ripen early and those which give good yields late in the season.

EARLY.	LATE.
Eureka,	Mills,
Hopkins,	Onondaga,
Mohler,	Palmer,*
Palmer,*	Pioneer.
Poscharsky No. 9,	

Desirable kinds.— The following list includes the varieties which have made a good record at this Station for several years and which can be recommended for trial where they have not already been tested. During some years, however, the best of these kinds were

*Unusually long season.

severely injured by anthracnose. It appears desirable to depend upon new plantations, as already indicated, rather than to look for anthracnose-proof kinds, although such varieties would be a great boon to the fruit grower, and possibly by careful selection and breeding, sorts immune to anthracnose may be developed.

Black Diamond,**	Hilborn,	Mohler,
Cumberland,	Lawrence,	Onondaga,
Eureka,	Livingston,	Palmer.
Gregg,	Mills,	

DESCRIPTION OF VARIETIES.

Beyer.— (Hugo Beyer, New London, Ia.) This is an Iowa seedling introduced by Mr. Beyer, and received for testing at this Station in 1904, fruiting for the first time in 1905. Plants moderately vigorous, apparently healthy although the foliage is rather light green or faintly tinged with yellow. Blossoms clustered at the ends of the shoots, and also for some distance towards the base of the shoots. Ripe berries and blossoms found on the same canes. Fruit below medium to medium, firm, seedy, not very juicy, rather acid, possibly good in flavor and quality. The claim is made that all of the canes should be cut down at the close of each season, the fruit being borne on the current year's growth. Requires further testing to fully determine its value but up to the present time has shown very few desirable characters.

Bishop.—(B. F. Smith, Lawrence, Kan.) Received at this Station for testing in 1897. Plants vigorous, healthy, nearly hardy, not very productive. Fruit averages medium to above, firm, rather dull unattractive color, covered with considerable bloom, rather seedy, moderately juicy, fair to good in flavor and quality. Not equal to standard varieties.

Black Diamond.—(C. W. Stuart & Co., Newark, N. Y.) Introduced by Stuart & Co., about ten years ago. Plants vigorous, nearly hardy, productive. Fruit variable in size, below medium to large, moderately firm, nearly sweet, good black color, fair quality. During the past few years this variety has made a poor showing at this Station. As it has made a very good record in other

**See description.

localities in Western New York, it appears to be worthy of further testing before being discarded.

Cumberland.—(Ellwanger & Barry, Rochester, N. Y.) Originated a number of years ago by David Miller, Harrisburg, Pa. Origin doubtful but supposed to be a seedling of Gregg. Plants vigorous, only a moderate amount of winter injury during the past four years, usually productive. Fruit medium to large, attractive black color, juicy, rather sweet when fully ripe, firm, good to very good in flavor and quality. One of the most desirable kinds for commercial purposes.

Eureka.—(W. N. Scarff, New Carlyle, O.) Said to have been found growing wild on the farm of Jacob Smith, Miami Co., Ohio. Plants moderately vigorous, winter injury varied from 15 to 25 per ct. during the past three years, usually productive. Fruit medium to very large, attractive black color, grains medium size, firm, sweet, mild, fair to good in flavor and quality. This is a standard variety in many localities, and is one of the early fruiting desirable kinds for commercial purposes.

Gregg.— An old variety received from various sources for testing at this Station. Found growing wild on the Gregg farm, Ohio Co., Ind., in 1866. Plants vigorous, moderately hardy, moderately productive to productive. Fruit above medium to very large, attractive black color, firm, rather sweet when fully ripe, good to very good in flavor and quality. An old standard sort valuable on account of its size and quality, although not as productive as some other varieties.

Hallock No. 1.—(N. Hallock, Queens, N. Y.) Received for testing in 1898. Plants rather weak growers, canes slender, moderate amount of winter injury. Fruit medium or below, moderately firm, slightly acid, fair quality. Not equal to standard kinds.

Hilborn.—(F. R. Palmer & Son, Mansfield, O.) A chance seedling originating on the grounds of W. W. Hilborn over twenty-five years ago. Plants vigorous to very vigorous, healthy, nearly hardy, productive. Fruit medium to large, firm, sweet, good to very good in flavor and quality. Has many qualities that commend it for commercial planting.

Hopkins.—(A. M. Purdy, Palmyra, N. Y.) A seedling found near Kansas City, Mo., in 1872 and introduced by Frank Holsinger,

Rosedale, Kan. Plants moderately vigorous, usually rather hardy, moderately productive. Fruit above medium to very large, nearly firm, grains medium size, attractive black color, sweet, good in flavor and quality. An old variety which has made a fair showing in some parts of the State, but is not as productive as some other varieties.

Kansas.— (A. H. Griesa, Lawrence, Kan.) A chance seedling originated by Mr. Griesa in 1884. Plants moderately vigorous, winter injury varied from 5 to 25 per ct. during the past five years, productive. Berries variable in size, medium to very large, good black color, grains medium size, sometimes inclined to crumble, rather seedy, moderately juicy, firm, mild, good flavor and quality. Has been tested for a number of years at this Station but has not made as good a record as some of the other black raspberries.

Lawrence.—(A. H. Griesa, Lawrence, Kan.) Originated by Mr. Griesa. Plants vigorous, nearly hardy, productive. Fruit above medium to large, moderately firm, attractive black color, fair to good in flavor and quality. Has many points that commend it for commercial purposes but is slightly lacking in quality.

Livingston.—(C. W. Middleton, Utica, Mo.) A seedling that is supposed to be a cross between Gregg and Tyler. Plants vigorous to very vigorous, winter injury from 10 to 15 per ct. during the last three years, productive. Fruit medium to large, grains medium size, attractive black color, firm, mild, good in flavor and quality. The variety has made a good showing at this Station and appears to be worthy of more extended trial.

Lovett.—(J. T Lovett, Little Silver, N. J.) Originated by Mr. Ezra Wood, Jefferson County, Ind., and introduced in 1891 by Lovett & Co. Plants moderately vigorous, canes rather slender, slight amount of winter injury, moderately productive to rather productive. Fruit medium to large, attractive black color, moderately firm, sweet, fair to good flavor and quality. Although this variety has many desirable qualities, it does not appear to be any improvement on standard kinds.

Manwaring No. 1.—(C. H. Manwaring, Lawrence, Kan.) A seedling of an unknown parentage originated by Mr. Manwaring. plants moderately vigorous, canes rather slender, dwarfish, usually hardy, moderately productive. Fruit small to medium, attractive

black color, moderately firm, mild subacid, lacking in flavor and quality. Does not appear to be desirable.

Mills.—(Charles Mills, Fairmount, N. Y.) A seedling of Gregg crossed by Tyler, originating with Mr. Mills. Plants vigorous to very vigorous, winter injury from 0 to 15 per ct. for the past four years, productive. Fruit above medium to large, firm, rather dull black with considerable bloom; good flavor and quality. A desirable kind for commercial purposes.

Mohler.— (D. M. Mohler & Co., New Paris, O.) Originated as a seedling of Eureka by Mr. Mohler. This variety was quite fully described in the annual reports of this Station for 1894 and 1895, and appeared at that time to be worthy of extended trial on account of its size and productiveness. It has continued to make a good record at this station, and is considered worthy of testing where it has not yet been tried. It ranks among the earliest ripening varieties.

Ohio.— An old well known variety received from various sources for testing at this Station. Fifteen years ago this was one of the most popular of commercial varieties, but it is being superseded by better kinds. It is still being grown, however, in certain parts of the State for drying purposes.

Older.—An old variety received from various sources for testing at this Station. Found growing wild in the garden of Mr. Older, Independence, Ia, in 1872, and introduced by L. K. Ballard, Warren, Ill. Plants vigorous, moderate amount of winter injury, moderately productive. Fruit variable in size, ranging from medium to large, moderately firm, moderately juicy, slightly acid, good flavor and quality. Hardly equal to such varieties as Mills or Cumberland.

Onondaga.—(Charles Mills, Fairmount, N. Y.) A seedling of Gregg crossed by Tyler, originating in 1884 with Mr. Mills. Plants vigorous to vigorous, winter injury from 0 to 15 per ct. during the past five years, productive to moderately productive. Fruit large, of attractive black color, firm or nearly so, good flavor and quality. This variety has many good points which commend it for commercial purposes.

Palmer.—This variety has been received from various sources for testing at this Station during the past twelve years. Originated by F. L. Palmer, Mansfield, Ohio, and introduced in 1888. Plants moderately vigorous to vigorous, winter injury from 0 to 50 per ct. during the past five years, moderately productive. Fruit medium to above, rather dull black, firm, grains medium to below, nearly sweet, good in flavor and quality. Although the berries lack somewhat in size, and the plants in productiveness, it is nevertheless considered valuable in many localities on account of its earliness. It is one of the first of the black raspberries to ripen.

Perpetual King.—(Columbian Grape Co., Kingston, O.) Received for testing at this Station in 1897. Plants not vigorous, dwarfish, canes thickly covered with prickles and often covered with bluish bloom, rather tender, not productive. Fruit medium to large, rather unattractive black, moderately firm, slightly acid, fair quality. Undesirable.

Poscharsky No. 9.—(F. W. Poscharsky, Princeton, Ill.) This seedling which originated with Mr. Poscharsky, has been tested here for a number of years. Plants moderately vigorous, rather weak canes, rathre hardy, moderately productive. Fruit variable in size, ranging from small to nearly large, grains small and compact, moderately firm, good black color, rather acid, fair to good in quality. Undesirable.

Rowena.—(J. P. Stahelin, Bridgman, Mich.) An accidental seedling found by Mr. Stahelin, from whom the plants were received in 1897. Plants vigorous to very vigorous, usually rather hardy, rather productive. Fruit below medium to nearly large, rather dull black with considerable bloom, firm, grains medium size, fair to good flavor and quality. Inferior to standard kinds.

Townsend No. 2.—(G. Townsend, Gordon, O.) Originated from seed of Gregg by Mr. Townsend. Plants vigorous to very vigorous, usually hardy, rather productive. Fruit medium to large, not particularly attractive in color on account of heavy bloom, grains medium to above, firm, sometimes inclined to crumble, somewhat seedy, sweet, good flavor and quality. Inferior to standard kinds.

BLACKBERRIES.

NOTES ON VARIETIES.

Hardiness.— Blackberry culture is of comparatively little importance in New York. Blackberry growing largely resolves itselt into an effort to grow only those kinds fairly hardy under New York conditions. It is probable that in a few sections of the State winter protection of a few desirable kinds would prove profitable, as several most excellent sorts are somewhat tender. The following is a list of the hardy and tender sorts. Observations were made for several years; the list of hardy sorts includes those not injured over 25 per ct.; the list of tender ones, those injured severely, in some cases as high as 90 per ct.

HARDY OR NEARLY SO.	NOT HARDY.	
Agawam,	Allen,	Florence,
Ancient Briton,	Black Chief,	Ida,
Chautauqua,	Bow Cane,	Kittatinny,
Eldorado,	Childs Tree,	Lovett,
Fruitland,	Clark,	Mersereau,
New Rochelle,	Clifton,	Minnewaski,
Ohmer,	Dorchester,	Rathbun,
Snyder,	Early Harvest,	Reyner,
Stone Hardy,	Early King,	Success,
Taylor,	Early Mammoth,	Wilson Jr.
Tyler,		
Wachusett,		

Earliness.— The time of fruiting varies so much that no very satisfactory list as to season can be given. Some varieties have a long season, others ripen early or late, depending on character of soil and exposue. The following is a list of those varieties from which fruit was picked. early in the season and those giving good yields near the close of the season.

EARLY.	LATE.
Agawam,*	Agawam,*
Allen,	Ancient Briton,
Early Harvest,	Chautauqua,
Early King,	Childs Tree,
Eldorado,	Florence,
Minnewaski,	Mersereau,
Rathbun,	Ohmer,
Wilson Jr.,	Success,
	Taylor,
	Tyler.

*Long season.

Desirable kinds.—Not all of the varieties in the following list are hardy nor is the fruit of some of the kinds very large. The varieties, however, have made good records for several years in some parts of the State and are worthy of consideration although it cannot be expected that very many of them will be entirely satisfactory in the same locality.

Agawam,
Ancient Briton,
Chautauqua,
Early Harvest,
Eldorado,
Kittatinny,
Mersereau,
Minnewaski,
New Rochelle,
Ohmer,
Rathbun,
Snyder,
Success.

THE LONG-CLUSTER BLACKBERRIES.

(*Rubus nigrobaccus.*)

DESCRIPTION OF VARIETIES.

Allen.—(W. B. K. Johnson, Allentown, Pa.) Received at this Station for testing in 1900. Plants moderately vigorous, rather dwarf, winter injury varying from 5 per ct. to 75 per ct. during the past four years, rather productive. Fruit rather small, elongated, good attractive black color, firm, mild in flavor when fully ripe, good quality. In appearance the fruit closely resembles Early Harvest and is fully as early in its season of ripening. So far as tested at this Station does not appear to be very hardy, and on account of dwarf habit of growth is not as productive as some of the taller-growing standard varieties.

Ancient Briton.—(Ellwanger & Barry, Rochester, N. Y.) An old, well-known variety which was first brought to notice in Wisconsin. It is said to have been brough to this country from Great Britain about fifty years ago. Plants moderately vigorous to vigorous, stocky, with an abundance of large prickles, winter injury from 0 to 25 per ct. during the past five years, productive to very productive. Fruit medium to above, possibly averaging slightly below Agawam but larger than Snyder, slightly elongated, good black color, mild when fully ripe, good to very good in flavor and quality. Somewhat resembles the Agawam in size, color and quality and is considered a standard berry for commercial purposes.

Chautauqua.— (K. E. Downer, Forestville, N. Y.) Plants of this variety were received for testing in the spring of 1903, fruiting for the first time in 1905. Winter injury from 5 to 10 per ct. during the past two years. Plants vigorous, stocky, rather productive. Fruit large, inclined to roundish, attractive black color, grains large, rather agreeable acid when fully ripe, good flavor and quality. Has not yet been sufficiently tested to determine its value but appears to be promising.

Clark.— (M. Crawford Co., Cuyahoga Falls, O.) Received at this Station for testing in the spring of 1897. Plants vigorous, making a very satisfactory growth, winter injury from 0 to 50 per ct. during the past five years, moderately productive to rather productive. Fruit late in ripening, below medium to above medium in size, nearly round to slightly elongated, moderately acid, rather soft, no more than good in flavor and quality. Does not appear to be as valuable as standard varieties like Agawam, Mersereau, etc., as the fruit is variable both in size and shape while the color is rather unattractive dull black.

Eldorado.—(Birdseye & Son, Stanley, N. Y.) A chance seedling found near Eldorado, Ohio, and introduced about 1882. Plants have been received from various places for testing. Moderately vigorous to vigorous with numerous large prickles, moderately productive to productive. Appears to be one of the hardiest at this Station averaging in 6 years from 5 to 25 per ct. winter injury with no injury during four years. Fruit medium to large, roundish to slightly elongated, sweet, juicy, good color, mild when fully ripe, fair to good in flavor and quality. Has made a good record in many parts of the State as a commercial variety.

Florence.—(G. E. Goldsmith, Unionville, N. Y.) A seedling of unknown parentage found by Mr. Goldsmith in 1895. Received at this Station for testing in the spring of 1902, fruiting for the first time in 1904. Growth rather vigorous, winter injury varied from 15 to 75 per ct. during the past two years, appears rather productive. Fruit variable in size, medium to very large, usually roundish, sometimes slightly elongated, rather attractive color, grains rather large, juicy, not a mild berry even when fully ripe, possibly good but not high in flavor or quality. Has not yet been

sufficiently tested at this Station to determine its value but appears to be rather tender in this locality.

Ohmer.—(N. H. Albaugh, Tadmore, O.) Introduced over ten years ago by E. Y. Teas, Irvington, Ind. Plants moderately vigorous, canes rather large with but few prickles, winter injury from 10 to 20 per ct. during the past three years, moderately productive. Fruit above medium, roundish, grains large, juicy, rather acid even when fully ripe, good flavor and quality. Although not as productive as some varieties, has made a fairly good record at this Station.

Reyner.—(S. R. Alexander, Bellefontaine, O.) Plants vigorous, healthy, canes large, tinged with green, covered with few prickles, winter injury from 10 to 30 per ct. during the past three years, not very productive. Fruit medium to above, roundish or slightly elongated, grains large, rather sweet when fully ripe, good flavor and quality. As fruited at this Station, hardly productive enough to be a good commercial variety.

Taylor.—An old variety received from several sources for testing at this Station. Said to have originated in Indiana over twenty years ago. Plants vigorous to very vigorous, canes pale green with slight tinge of red and covered with numerous slender prickles, usually hardy, not very productive. Fruit small to medium, usually slightly elongated, rather sweet when fully ripe, very good flavor and quality. Ripens about two weeks later than Snyder. Although of excellent quality and hardy, is not as productive as Snyder and does not appear to be as desirable for this locality as some of the other well known varieties.

Wachusett.—An old variety which has never become very popular in this State. Said to be one of the most hardy varieties; found growing wild on Mt. Wachusett. Plants moderately vigorous, canes medium size, purplish red when fully mature, covered with small scattering prickles, hardy, usually not productive. Fruit small to medium, roundish or slightly elongated, juicy, sweet, good flavor and quality. Is not productive enough to be of much value in this section.

THE SHORT-CLUSTER BLACKBERRIES.

(*Rubus nigrobaccus,* var. *sativus.*)

DESCRIPTION OF VARIETIES.

Agawam.—(From bed in Station grounds.) A wilding found in a pasture between 1865 and 1870 by John Perkins, Ipswich, Mass. Plants vigorous to very vigorous, above medium to tall, stout, numerous, prickles comparatively few and small, winter injury from 0 to 25 per ct. during the past five years, very productive. Fruit above medium to medium, usually slightly elongated, attractive bright black color, mild when fully ripe, good to very good in flavor and quality. This is a well known standard variety which has made a good record commercially in many places. Although the fruit is not of the largest size it is of excellent color, desirable flavor and quality, averages larger than Snyder, is very productive and ships well.

Black Chief.—(J. H. Haynes, Delphi, Ind.) Plants very vigorous, greenish, with numerous small prickles, unproductive; winter injury varying from 10 to 85 per ct. during the past five years. Fruit medium size, roundish, grains medium, very mild, sweet when fully ripe, good flavor and quality. Appears to have but little value in this section as the canes are not hardy and the plants are rather unproductive.

Fruitland.—(W. N. Scarff, New Carlyle, O.) Plants vigorous to very vigorous, upright, canes tinged with greenish red, with moderately numerous prickles; winter injury varied from 10 to 25 per ct. for the past three years, not productive. Fruit medium, roundish, grains variable in size, rather sweet, good to very good flavor and quality. Not equal to standard varieties.

Kittatinny.—(Slaymaker & Son, Dover, Del.) Said to be a seedling found in the Kittatinny Mountains, Warren Co., N. J. Plants moderately vigorous to rather vigorous, canes reddish color when mature, covered with many large prickles, winter injury varied from 5 to 40 per ct. during the past four years, usually only moderately productive on account of winter injury to canes. Frequently attacked by orange rust. Fruit above medium to large, usually slightly elongated, attractive black color, juicy, agreeably mild when fully ripe, good to very good in flavor and quality. One

of the oldest varieties, and of considerable value commercially in sections where it is not injured by the winter and when not attacked by orange rust. Is not considered very hardy in Western New York.

Lovett.—(J. T. Lovett, Little Silver, N. J.) Plants vigorous to very vigorous, canes upright, covered with numerous, rather large prickles, winter injury varied from 0 to 50 per ct. during the past four years, unproductive. Fruit small to medium, nearly sweet when fully ripe, grains variable, good flavor and quality. Not equal to standard varieties.

Mersereau.—(J. W. Mersereau, Cayuga, N. Y.) Said to be a seedling of Snyder found by Mr. Mersereau, growing among his Snyder bushes over twelve years ago. Plants vigorous to very vigorous, healthy, canes medium size, with moderate amount of prickles, winter injury varied from 5 to 50 per ct. during the past five years, averaging only 5 per ct., however, for three years; productive. Fruit usually above medium to large, roundish to slightly elongated, attractive black color, medium sized grains, juicy, mildly sweet when fully ripe, rather sprightly, good flavor and quality. Has made a good record in many parts of the State and is already being grown commercially in many places. Generally considered one of the most desirable kinds, and is certainly worthy of trial where it has not yet been tested.

Minnewaski.—Plants have been received and tested from various sources. Originated over twenty-two years ago by A. J. Caywood & Son, Marlboro, N. Y., and is a cross of Kittatinny and a wild blackberry. Plants moderately vigorous to rather vigorous, canes usually slightly tinged with red, with numerous branches and thickly covered with prickles; winter injury varied from 15 to 50 per ct. during the past five years; usually moderately productive when not injured by the winter. Fruit above medium to large, roundish to slightly elongated, sweet and juicy when fully ripe, good in flavor and quality. It is rather tender and largely on this account has never become very popular as a commercial variety.

New Rochelle.—(Ellwanger & Barry, Rochester, N. Y.) This variety is known in some places as the Lawton. Said to be a wilding found by the roadside and introduced into the gardens of New Rochelle, N. Y. Described by E. P. Roe, New York, in 1875, as

an old and well known variety. Plants vigorous, canes stocky, covered with numerous rather large prickles; winter injury varied from 10 to 25 per ct. during the past five years; moderately productive to productive. Fruit large to medium, usually slightly elongated, attractive black color, juicy, nearly sweet when fully ripe, good in flavor and quality. In some localities it is reported as rather tender, but has made a good record at this Station, the average winter injury for three years in succession being only 10 per ct.

Snyder.—An old variety, plants of which have been received from various sources for testing. A wilding found in Northern Indiana over fifty years ago. Plants vigorous to very vigorous, healthy, canes large, upright, covered with numerous large prickles, very little if any winter injury during the past five years, productive. Fruit medium to small, roundish, color often inclined to become unattractive unless berries are fully mature before picking, juicy, pleasant flavored, good quality. A valuable standard commercial variety grown in many places on account of its hardiness, although the berries are inclined to run rather small, and under unfavorable conditions the color becomes a dull brownish red.

Stone Hardy.—(S. E. Hall, Cherry Valley, Ill.) Said to be a chance seedling found in Illinois, and introduced over twenty years ago. Plants moderately vigorous to rather vigorous, canes rather slender, upright, covered with numerous long prickles, hardy, productive. Fruit small to medium, averaging about the same as Snyder, roundish, juicy, nearly sweet, good in flavor and quality. Does not appear to be as popular as Snyder which variety it resembles in many respects.

Success.—(L. W. Carr & Co., Erie, Pa.) Plants moderately vigorous, canes tinged with green and covered with numerous prickles, winter injury varied from 0 to 50 per ct. for the past five years, moderately productive to productive. Fruit variable in size, averaging above medium, grains medium size, roundish, juicy, good color, good in flavor and quality. Appears to be quite hardy when the canes are properly ripened, the average winter injury for three years being only 4 per ct.

Tyler.—(Birdseye & Son, Stanley, N. Y.) Plants vigorous to very vigorous, nearly hardy, the winter injury varying from 0 to 5 per ct. for the past six years, moderately productive to productive. Fruit above medium to small, usually slightly elongated, variable both in size and shape, nearly sweet, fair to good in flavor and quality. In general appearance is not equal to such varieties as Agawam, Ancient Briton or Eldorado. It is, however, one of the hardiest varieties, but does not equal Snyder in productiveness.

Clifton.*—(L. J. Clifton, Memphis, N. Y.) Plants received at this Station for testing in the spring of 1898. Moderately vigorous to vigorous, winter injury 0 to 50 per ct. during the past five years, rather productive. Fruit varies in size from small to large, attractive black color, roundish to slightly elongated, agreeable acid, good flavor and quality. Appears to be worthy of testing if it will endure ordinary winter exposure, but it seems to be rather tender, as the average winter injury for the past two years was 50 per ct.

THE LEAFY-CLUSTER BLACKBERRIES.

(*Rubus argutus.*)

DESCRIPTION OF VARIETIES.

Dorchester.—(Ellwanger & Barry, Rochester, N. Y.) An old well known variety originating in Dorchester, Mass., and introduced in 1850. Plants moderately vigorous to vigorous, upright, with numerous small prickles, winter injury from 10 to 50 per ct. during the past five years, productive. Fruit medium size, elongated, attractive black color, moderately sweet, good in flavor and quality but hardly equal to Agawam in flavor or productiveness.

Early Harvest.—(Slaymaker & Son, Dover, Del.) This old variety is said to have originated in Southern Illinois. Plants moderately vigorous, tinged with red, covered with comparatively few, small prickles, winter injury varied from 0 to 75 per ct. for the past six years, moderately productive to rather productive. Fruit medium size, usually slightly elongated, good color ,mild when fully ripe, very juicy, fair to good in flavor and quality. One of the earliest to ripen and is valuable only for this reason.

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*Species in doubt.

Early King.—(Ellwanger & Barry, Rochester, N. Y.) Fruited at this Station for a number of years. Plants moderately vigorous to vigorous, purplish when mature, canes of medium size, prickles long, numerous. Ripening about a week earlier than most varieties but rather unproductive as is usual with early varieties. Winter injury from 5 to 80 per ct. during the past five years. Fruit medium size, roundish or slightly oblong, usually attractive color, only fair to good in flavor and quality.

Ida.—Received for testing at this Station in 1898 from Thompson Sons, Rio Vista, Va. A seedling of Early Harvest. Plants moderately vigorous, semi-dwarf, unproductive to rather productive, winter injury from 0 to 75 per ct. for the past four years. Fruit medium size, elongated, rather dull black, not particularly attractive, juicy, fair in flavor and quality. So far as tested, is inferior to standard varieties at this Station.

THE LOOSE-CLUSTER BLACKBERRIES.

(*Rubus nigrobaccus* x *villosus.*)

DESCRIPTION OF VARIETIES.

Bow Cane.*—(Broome Bros., McLoud, Okla.) Plants received at this Station for testing in 1900. Moderately vigorous, very dwarfish or trailing somewhat like a dewberry, winter injury varied from 10 to 90 per ct. during the past four years, unproductive. Fruit medium in size, unattractive in color, roundish to slightly elongated, grains large, rather acid, fair to good in flavor and quality. So far as tested at this Station does not appear to be valuable on account of unproductiveness, inferior quality and tendency to severe winter injury.

Early Mammoth.—(Cleveland Nursery Co., Rio Vista, Va.) Said to be a hybrid between the blackberry and dewberry, and much resembles Wilson Jr. in habit of growth. Plants moderately vigorous, tinged with red, covered with numerous slender prickles, winter injury varied from 20 to 50 per ct. during the past three years, productive when not injured by winter. Fruit variable in size, ranging from small to very large, often imperfectly developed,

*Species in doubt.

attractive bright color, usually slightly elongated, grains large, very juicy, rather tart when fully ripe, fair to good in flavor and quality. Appears to be too tender to be grown in this locality without winter protection.

Rathbun.—(Slaymaker & Son, Dover, Del.) Plants received at this Station for testing in 1896. Bushes only moderately vigorous, only medium height, winter injury varied from 10 to 90 per ct. for the past six years, moderately productive when not severely injured by winter. Fruit medium to very large, usually slightly elongated, attractive black color, rather mild when fully ripe, fair to good in flavor and quality. Although the fruit is very desirable in size, the bushes are rather small and the amount of winter injury has been very severe in some years. Does not appear to be hardy enough for this locality.

Wilson Jr.—(Birdseye & Son, Stanley, N. Y.) This old variety has been fruited for a number of years at this Station. It was originated by William Parry, Parry, N. J., in 1875, and it is said to be a seedling of Wilson Early. Plants intermediate between dewberries and blackberries with low habit of growth, moderately vigorous, canes with slight tinge of red, winter injury varied from 0 to 50 per ct. for the past five years, only moderately productive when not injured by the winter. Fruit variable in size, medium to very large, roundish to slightly elongated, grains large, sometimes imperfectly developed, very juicy, rather acid even when fully ripe, good to very good in flavor and quality. The habit of growth is not very desirable and the canes need winter protection in this locality.

THE SAND BLACKBERRY.

(*Rubus cuneifolius.*)

DESCRIPTION OF VARIETIES.

Childs Tree.—(J. L. Childs, Floral Park, N. Y.) Plants numerous, rather slender, very dwarf, covered with many prickles, not productive, winter injury from 10 to 90 per ct. during the past four years. Fruit not uniform in size, ranging from small to above medium, roundish to slightly elongated, rather acid, not equal to standard kinds in flavor or quality. Plants have been tested at this Station since 1894 and appear to have no value in this locality.

CULTURAL DIRECTIONS.

Introduction.— In discussing the growing of these fruits the work is not taken up in detail to give full and explicit directions, but attention is briefly called to some of the most important subjects connected with the successful growing of the crop. The details will vary to suit the different conditions under which the plants may be grown.

Soil.— Raspberries and blackberries are nearly as cosmopolitan as strawberries in regard to adaptation to soils. Deep moderately sandy loams or clay loams containing an abundance of humus usually give best results with raspberries, while blackberries are often at their best on a slightly heavier soil. It is important that the soil be not too wet as this condiion often increases the amount of winter injury.

Fertilizers.— There is no one brand of fertilizers best suited to raspberries and blackberries under all conditions. The kind of plant food to use depends largely on the amount and kind already in the soil and also somewhat on its physical condition. Some soils lack nitrogen, others potash or phosphoric acid and many are deficient in humus which not only supplies plant food but also aids greatly in the retention of moisture. Stable manure and cover crops are available for supplying humus. Care must be used in making applications of nitrogenous fertilizers or the resulting growth will not mature, a condition which may cause severe winter injury. If the soil is already rich in humus, it would appear desirable in some cases to avoid the use of stable manure, using commercial fertilizers in its place. Wood ashes, muriate of potash, acid phosphate, etc., are valuable where needed. The best way to determine the kind and amount to use is by trial, leaving check rows for comparison.

Preparation of land.— Raspberries and blackberries, unlike strawberries, occupy the soil for a number of years, and for this reason the preparation should be very thorough. If too wet the land should be underdrained. If for one or two years preceding, hoed crops have been used, there will be fewer weeds to fight. The land should be well plowed and thoroughly fitted to receive the plants.

Selection of varieties.— Plant mainly only those kinds that appear to succeed in the immediate locality, testing newer ones in a small way. The varities best suited for one set of conditions may be failures elsewhere. In another part of this bulletin are given lists of varieties found desirable in many parts of the State but it cannot be expected that all will do equally well in the same locality.

Propagation and selection of plants.— Red raspberries are usually propagated by transplanting the numerous suckers which come up freely around the original hills. Black raspberries are increased by rooting the tips of the nearly mature canes in late August or early September. The ends of the canes are covered lightly with earth, and by late fall a large mass of fibrous roots will be formed with a well developed crown. Varieties of purple raspberries are hybrids, produced by crossing red and black raspberries, and some of them may be propagated either by using suckers or by rooting the tips of the canes. Blackberries do not sucker as freely as the red raspberries. These suckers have but few fibrous roots and as a rule do not make such good plants as those started from cuttings of the blackberry roots. The roots may be dug in the fall, cut into two or three inch lengths, stratified over winter and sown in nursery rows in the spring and most excellent plants are usually obtained after one season's growth. Only strong healthy plants should be selected, and it is often an advantage to choose these from a younger plantation rather than from an old bed the plants of which may have deteriorated in vigor and may be infested with various insects and diseases.

Setting the plants.— Blackberries and red raspberries may be set either in the fall or in the early spring. If set in late October or early November the rows should be plowed up to, making a back furrow along each row of plants. This will be a great protection against winter injury. The earth should be taken away from the hills as soon as the ground is in working order in early spring. Such plants, as a rule, start into growth earlier than those set in the spring. These plants should be set as deep, or slightly deeper, than they were in the original beds. Black raspberry plants and the purple kinds rooted from the cane tips

should be set in the spring instead of the fall, not covering the crown too deeply, and spreading the roots in a circle about the center of the crown. It is an advantage to set the plants in the bottom of a shallow furrow, filling in as the plants develop. Under these conditions they withstand drought better and the canes are not so easily blown over by the wind.

The distance apart of rows and of plants depends on the system of cultivation, the varieties, the natural richness of the ground and the location. In general the plants should not be crowded, Red raspberries may be set closer than black raspberries and blackberries should be set the farthest apart. These distances may vary from three by six feet to four by eight feet depending on conditions.

Subsequent treatment.— The ground should be kept well cultivated and the plants hoed as occasion requires. In young plantations, if the plants have been set properly, cultivation may be given both ways thus reducing the expense of keeping down the weeds. The cultivation should be shallow as the roots lie near the surface. On heavy clay soils it may sometimes be desirable in some seasons to plow early in spring, following with the cultivator till fruiting time. During the picking of the fruit there is little opportunity to cultivate, but the ground should be thoroughly stirred as soon as the harvest is over. If desirable a cover crop may be sown in late August or early September.

During the first two years it is not always necessary to give the land solely to the berry plants. Potatoes, cabbages, strawberries, etc., are often grown with advantage between the rows so that a considerable income from this source may be obtained before the berry plants fully occupy the ground.

Pruning.— Summer pruning of red raspberries is not generally practiced but may often be done with advantage to black raspberries and blackberries. It consists in pinching or cutting off the tender ends or tips of the new shoots at a height that may vary from eighteen inches to twenty-four or even thirty, the blackberries usually being pinched somewhat lower than the black raspberries. The result of this pruning is the formation of rather low stocky plants with numerous lateral branches which will not

require a trellis. As the young plants do not all develop at the same time it is necessary to go over the plantation several times in order to pinch the growth at the proper height.

The canes growing one summer, bear fruit the next season and then die, while new canes develop each year for the succeeding year's crop. Frequently the canes which have fruited are allowed to remain until the following spring before removal, but better results are usually secured by cutting them out and burning as soon as the berry crop is harvested. By this method the insects and fungus diseases frequently infesting those canes may be destroyed, and the young canes have more room to develop. Each spring the plants should be gone over, cutting off the weak ends of the canes and thinning out some of the smaller ones where the growth is too dense. From three to five canes per hill are usually preferable to a larger number.

Winter protection.— The winter protection of the plants is largely confined to the colder climates, only those kinds being grown in this State commercially that withstand fairly well New York conditions. Blackberries are usually much more tender than raspberries. Winter protection consists in laying down the canes and covering them with a thin mulch of straw and earth.

THE RENOVATION OF WORN-OUT ORCHARDS.*

U. P. HEDRICK.

I. CAUSES OF WEARING OUT.

Old age.— Old age with orchard fruit is a relative term. In general, longevity depends upon the fruit, the variety and the environment. The profitable bearing age of the several fruits is longest in the apple followed in order by the pear, cherry, plum and lastly the peach. Some verieties live longer than others. Peaches live from fifteen to twenty years; plums, twenty to thirty; cherries, thirty to forty; pears and apples fifty to eighty. Many orchards are too old to be worth renovation.

Climate.— A deleterious change in climate is often assigned as a reason for the deterioration of orchards. Records show that climate in this region changes but little, though it does swing slightly from hot to cold and from wet to dry in cycles of a decade or less. Such changes do not greatly affect an apple or a pear generation but might shorten and reduce the value of a peach generation. The slight changes in climate do not greatly affect orchards.

Insects and fungi.— Insects and fungi contribute much to the downfall of orchards. They are continually increasing in kinds and in individuals. The kinds increase by importation from foreign countries and because, as natural food is destroyed by the destruction of wild vegetation, pests are driven to cultivated plants. The individuals of the innumerable kinds are increasing because orchard areas are becoming more closely united and so, as disease spreads faster in a city than in the country, pests multiply as their feeding grounds become more compact.

Lack of care.— Many orchards are worn out because they have been neglected. It is the exception to find an orchard that has

*A reprint of Circular No. 6. new series.

been given the care usually given to other cultivated plants. The orchard, too often, is cared for as a whole; consideration is given to tree and tree alike, rather than to the individual in accordance with particular needs. To keep trees from wearing out requires that they be cared for assiduously in many particulars and as individuals rather than in mass. Trees respond to good care just as corn, potatoes, strawberries or any of the highly tilled crops do.

Depletion of soil fertility.— The food account in many orchards has been overdrawn. Proofs are: Plant a young tree in the place of an old one and it dies or suffers from starvation; well-fed orchards are more fruitful, the trees are larger, more vigorous, the fruit of better quality, and the trees are longer-lived; feed a worn-out orchard and the trees revive and approximate their former vigor. Soil exhaustion is the most potent cause of orchard deterioration.

II. RENEWING WORN-OUT ORCHARDS.

Reduce the number of trees if they stand too thickly.— There is always a tendency to plant too many trees to the acre, with the result that the orchard deteriorates from overcrowding. Usually the first step in renovating a worn-out orchard is to cut down a part of the trees. Before branches begin to touch, trees should be thinned.

Prune thoroughly.— But few worn-out orchards have been well pruned, a condition manifested by unsymmetrical heads, decaying branches, too many branches and a great growth of water sprouts. Such orchards should be pruned to correct the defects mentioned; to let in light and air; to facilitate orchard operations; and, with an additonal cutting back of some good wood, to increase the vigor of the tree. Prune in late winter; make the wound as near the tree trunk as possible and parallel with it; cover large wounds with lead paint; have an ideal in mind as to the shape of the tree desired and prune strong growing varieties lightly and weak growing ones severely.

Drain wet lands.— Many orchards are on soils too wet to grow good trees. Such soils should be drained and all wet, sour spots so commonly found in old orchards should receive attention.

Enrich the soil.— Nearly all worn-out orchards imperatively demand more food. Stable manure or cover crops and potash

and phosphoric acid in varying combinations to suit different conditions, are the chief essentials for feeding worn-out orchards. Some soils require a good liming. Nitrogen is best supplied through an occasional cover crop of clovers. Stable manure may be needed to improve the physical conditions of the soil as well as to supply food. With the nitrogen supplied with a cover crop, an annual dressing of one part each of acid phosphate, ground bone and muriate of potash at the rate of from one thousand to fifteen hundred pounds per acre should be applied; these fertilizers should be varied in accordance with the soil, kind of fruit, variety, and age and vigor of the trees. Apply fertilizers before growth starts in the spring and work them in with a cultivator.

Remove old bark and diseased portions of trunk and limbs.— The shaggy bark of old trees harbors injurious insects and fungi and often indicates a hidebound condition of the tree. With a short-handled hoe scrape off this rough bark. With a draw-shave or sharp knife remove all signs of cankers, body blights, gummosis, dead spots, borers or other troubles of the wood. Some or all of these are to be found in neglected orchards.

Put in practice a system of spraying.— Follow the above cleansing process, before buds swell, with a thorough spraying of strong copper sulphate — one pound to fifteen gallons of water — to destroy moss, lichens and fungi. Apply the seasonal sprayings for the several fruits. (Consult Bulletins 170 and 243 from this Station.)

Plow each Spring and cultivate through the growing season.— Worn-out orchards are usually in sod, and no matter what the system of tillage advocated may be, the breaking up of the sod, and subsequent tilling for several seasons must hold first place as a means of renovating old orchards. Turn up the soil, as shallow as possible at the first attempt, in the Spring and shake it out with the cultivator several times during the season that sunlight and air may enter in; that bacteria may live and work; that moisture may be conserved; that grass cannot take the cream of the land; and that the storehouses of potash and phosphoric acid may be unlocked.

Make yearly use of cover crops.— The soil of worn-out orchards is usually in poor physical condition and the most expedient way

of improving it is by plowing under cover crops. Cover crops, if legumes, also add nitrogen, and all add humus to the soil; rotate legumes, grains and cruciferous plants in accordance with the needs of the land and of the fruit. Sow cover crops when the trees have made the proper season's growth and plow under the following Spring.

Study the trees, the soil, and the particular conditions of each orchard.— No two worn-out orchards have reached the condition through the same causes; hence, no two require the same treatment in renovating. A special study must be made of each particular case to determine the treatment needed.

APPENDIX

I. Periodicals Received by the Station.

II. Meteorological Records.

APPENDIX.

PERIODICALS RECEIVED BY THE STATION.

Acclimitation	Complimentary.
Agricultural Epitomist	Complimentary.
Agricultural Experiments	Complimentary.
Agricultural Gazette of New South Wales	Complimentary.
Agricultural Journal and Mining Record (Natal)	Complimentary.
Agricultural Journal of the Cape of Good Hope	Complimentary.
Agricultural Ledger	Complimentary.
Agricultural News	Complimentary.
Allegan Gazette	Complimentary.
American Agriculturist	Subscription.
American Chemical Journal	Subscription.
American Chemical Society, Journal	Subscription.
American Cultivator	Complimentary.
American Entomological Society, Transactions	Subscription.
American Fancier	Subscription.
American Fertilizer	Subscription.
American Florist	Subscription.
American Grange Bulletin	Complimentary.
American Grocer	Complimentary.
American Hay, Flour and Feed Journal	Complimentary.
American Journal of Physiology	Subscription.
American Naturalist	Subscription.
American Philosophical Society, Proceedings	Complimentary.
American Poultry Journal	Complimentary.
American Poultryman	Subscription.
American Stock Keeper	Complimentary.
Analyst	Subscription.
Annales de l'Institut Pasteur	Subscription.
Annals and Magazine and Natural History	Subscription.
Annals of Botany	Subscription.
Archiv der gesammte Physiologie (Pflueger)	Subscription.
Archiv fuer Hygiene	Subscription.
Association Belge des Chimistes, Bulletin	Complimentary.
Australian Garden and Field	Complimentary.
Beet Sugar Gazette	Complimentary.
Beitrage zur Chemischen Physiologie und Pathologie	Subscription.
Berichte der deutschen botanischen Gesellschaft	Subscription.
Berichte der deutschen chemischen Gesellschaft	Subscription.
Better Fruit	Complimentary.
Biochemisches Centralblatt	Subscription.

Biological Bulletin	Subscription.
Biologisches Centralblatt	Subscription.
Blooded Stock	Complimentary.
Boletim da Agricultura	Complimentary.
Boletin de la Sociedad Nacional de Agricultura	Complimentary.
Boston Society of Natural History, Proceedings	Subscription.
Botanical Gazette	Subscription.
Botanische Zeitung	Subscription.
Botanisches Centralblatt	Subscription.
Botaniste, Le	Subscription.
Buffalo Society of Natural Sciences, Bulletin	Complimentary.
Bulletin of the Department of Agriculture, Jamaica	Complimentary.
Caledonia Era	Complimentary.
California Fruit Grower	Subscription.
Canadian Entomologist	Subscription.
Canadian Horticulturist	Complimentary.
Centralblatt fuer Agrikultur-Chemie	Subscription.
Centralblatt fuer Bakteriologie, etc.	Subscription.
Chemical News	Subscription.
Chemical Society, Journal	Subscription.
Chemiker Zeitung	Subscription.
Chemisches Centralblatt	Subscription.
Chicago Daily Drovers' Journal	Complimentary.
Chicago Dairy Produce	Complimentary.
Cincinnati Society of Natural History, Journal	Complimentary.
Colman's Rural World	Complimentary.
Columbus Horticultural Society, Journal	Complimentary.
Commercial Poultry	Complimentary.
Country Gentleman	Subscription.
Country World	Complimentary.
Criador Paulista	Complimentary.
Dairy and Creamery	Complimentary.
Dairy and Produce Review	Complimentary.
Elgin Dairy Report	Complimentary.
Elisha Mitchell Scientific Society, Journal	Complimentary.
Entomological News	Subscription.
Entomological Society of Washington, Proceedings	Subscription.
Entomologische Zeitschrift	Subscription.
Entomologist	Subscription.
Entomologists' Record	Subscription.
Fanciers' Review	Complimentary.
Farm and Fireside	Complimentary.
Farm and Live Stock Journal	Complimentary.
Farm Journal	Complimentary.
Farm Life	Complimentary.
Farm News	Complimentary.
Farm Poultry Semi-Monthly	Complimentary.
Farm, Stock and Home	Complimentary.

Farmers' Advocate	Complimentary.
Farmers' Call	Complimentary.
Farmers' Guide	Complimentary.
Farmers' Progress	Complimentary.
Farmers' Sentinel	Complimentary.
Farmers' Tribune	Complimentary.
Farmers' Visitor	Complimentary.
Farmers' Voice	Complimentary.
Feather	Subscription.
Feathered World	Subscription.
Floral Life	Subscription.
Florists' Exchange	Subscription.
Flour and Feed	Complimentary.
Flour Trade News	Complimentary.
Fruit Grower	Complimentary.
Fuehling's Landwirtschaftliche Zeitung	Subscription.
Garden	Subscription.
Garden Magazine	Subscription.
Gardeners' Chronicle	Subscription.
Gardening	Subscription.
Gartenwelt	Subscription.
Gleanings in Bee Culture	Complimentary.
Green's Fruit Grower	Complimentary.
Hartwick Seminary Monthly	Complimentary.
Hedwigia	Subscription.
Herd Register	Complimentary.
Hoard's Dairyman	Complimentary.
Holstein-Friesian Register	Complimentary.
Holstein-Friesian World	Complimentary.
Homestead	Complimentary.
Horticulture	Subscription.
Horticultural Visitor	Complimentary.
Hygienische Rundschau	Subscription.
Indiana Farmer	Complimentary.
Insect World	Complimentary.
Ithaca Democrat	Complimentary.
Jahresbericht der Agrikultur-Chemie	Subscription.
Jahresbericht Garungs-Organismen	Subscription.
Jahresbericht der Nahrungs-und Genussmittel	Subscription.
Jahresbericht Pflanzenkrankheiten	Subscription.
Jahresbericht der Tier-Chemie	Subscription.
Jersey Bulletin	Complimentary.
Journal of Agricultural Science	Subscription.
Journal of Agriculture, Victoria	Complimentary.
Journal of Biological Chemistry	Subscription.
Journal de Botanique	Subscription.
Journal of the Dep't of Agriculture of Western Australia	Complimentary.
Journal of Experimental Medicine	Subscription.
Journal of Experimental Zoology	Subscription.

Journal fuer Landwirtschaft	Subscription.
Journal of Mycology	Subscription.
Journal of Physiology	Subscription.
Just's Botanischer Jahresbericht	Subscription.
Kimball's Dairy Farmer	Complimentary.
Landwirtschaftlicher Jahrbuch	Subscription.
Landwirtschaftlicher Jahrbuch der Schweiz	Subscription.
Landwirtschaftlichen Versuchs-Stationen	Subscription.
Live Stock and Daily Journal	Complimentary.
Live Stock Report	Complimentary.
Long Island Democrat	Complimentary.
Metropolitan and Rural Home	Complimentary.
Michigan Farmer	Complimentary.
Milch Zeitung	Subscription.
Milchwirtschaftliches Zentralblatt	Subscription.
Minnesota and Dakota Farmer.	Complimentary.
Mirror and Farmer	Complimentary.
Monthly Weather Review	Complimentary.
National Nurseryman	Complimentary.
National Farmer and Stock Grower	Complimentary.
National Stockman and Farmer	Complimentary.
Naturaliste Canadienne	Complimentary.
Nebraska Farmer	Complimentary.
New England Farmer	Complimentary.
New York Academy of Science, Annals and Transactions	Subscription.
New York Botanical Garden, Bulletin	Complimentary.
New York Entomological Society, Journal	Subscription.
New York Farmer	Complimentary.
New York Fruit and Produce News	Complimentary.
New York Tribune Farmer	Complimentary.
New Zealand Dairyman	Complimentary.
North American Horticulturist	Complimentary.
Northwest Pacific Farmer	Complimentary.
Ohio Farmer	Complimentary.
Ohio Poultry Journal	Subscription.
Pacific Coast Fanciers' Monthly	Subscription.
Photo-Miniature	Subscription.
Pacific Fruit World	Complimentary.
Popular Agriculturist	Complimentary.
Poultry Herald	Subscription.
Poultry Keeper	Complimentary.
Poultry Industry	Complimentary.
Poultry Monthly	Complimentary.
Practical Farmer	Complimentary.
Practical Fruit-Grower	Complimentary.
Praktische Blätter fuer Pflanzenschutz	Subscription.
Psyche	Subscription.
Queensland Agricultural Journal	Complimentary.
Rabenhorst's Kryptogamen-Flora	Subscription.

Reliable Poultry Journal	Subscription.
Republic	Subscription.
Revue Generale de Botanique	Subscription.
Revue Generale du Lait	Subscription.
Revue Horticole	Subscription.
Revue Mycologique	Subscription.
Royal Agricultural Society, Journal	Subscription.
Royal Horticultural Society, Journal	Subscription.
Rural New Yorker	Subscription.
Salt Lake Herald	Complimentary.
Saint Louis Academy of Science, Transactions	Complimentary.
Sanitary Inspector	Complimentary.
Science	Subscription.
Scientific American	Subscription.
Scientific Roll, Bacteria	Subscription.
Skaneateles Democrat	Complimentary.
Society of Chemical Industry, Journal	Subscription.
Societe Entomologique de France, Bulletin	Complimentary.
Societe Mycologique de France, Bulletin	Subscription.
Southern Planter	Complimentary.
Southern Tobacconist and Modern Farmer	Complimentary.
Southern Farm Magazine	Complimentary.
Southwestern Farmer and American Horticulturist	Complimentary.
Southwestern Farmer and Breeder	Complimentary.
Station, Farm and Dairy	Complimentary.
Stazione Sperimentale Agrarie Italiane	Complimentary.
Successful Farming	Complimentary.
Sugar Beet	Complimentary.
Texas Stockman and Farmer	Complimentary.
Torrey Botanical Club, Bulletins and Memoirs	Subscription.
Transvaal Agricultural Journal	Complimentary.
Up-to-Date Farming and Gardening	Complimentary.
Utica Semi-Weekly Press	Complimentary.
Wallace's Farmer	Complimentary.
West Indian Bulletin	Complimentary.
West Virginia Farm Review	Complimentary.
Western Fruit-Grower	Complimentary.
Western Plowman	Complimentary.
Zeitschrift fuer Analytische Chemie	Subscription.
Zeitschrift fuer Biologie	Subscription.
Zeitschrift fuer Entomologie	Complimentary.
Zeitschrift fuer Fleisch und Milch Hygiene	Subscription.
Zeitschrift fuer Hygiene und Infektions Krankheiten	Subscription.
Zeitschrift fuer Pflanzenkrankheiten	Subscription.
Zeitschrift fuer Physiologische Chemie	Subscription.
Zeitschrift fuer Untersuchung der Nahrungs und Genussmittel	Subscription.
Zoological Record	Subscription.
Zoologischer Anzeiger	Subscription.

METEOROLOGICAL RECORDS FOR 1906.

READINGS OF THE STANDARD AIR THERMOMETER.

1906.	January.			February.			March.			April.			May			June.		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	28.	31.	27.	29.	33.	31.	13.	22.	22.	32.	42.	42.	45.	56.	58.	67.	79.	70.
2	25.	26.	28.	—1.	0.	0.	17.	22.	25.	29.	40.	41.	50.	55.	67.	64.	73.	70.
3	23.5	30.	32.	8.	18.5	21.	34.	38.	39.	33.	53.	60.	48.	51.	50.	60.	74.	78.
4	40.	42.	37.	28.	30.5	37.	35.	35.	33.	41.5	60.	50.	48.	73.	67.	59.	77.5	80.
5	32.	31.5	30.	15.	10.	5.	27.	30.	30.	35.	43.	42.5	51.	58.	59.	69.	82.	74.
6	32.	32.	27.	—6.	4.	3.	16.	34.	40.	32.	40.	44.	52.	61.	57.5	71.	76.	80.
7	25.	30.	23.	—5.	13.	12.	32.	35.	33.	31.	41.	38.	47.	51.	48.	63.	80.	82.
8	13.	11.	10.	11.	26.	26.	32.	39.	40.	33.	44.	44.5	40.	51.	49.	71.	84.	90.
9	10.	12.	12.	24.	30.	27.	33.	37.	35.	40.	40.	37.	43.	49.	42.	72.	81.	79.
10	16.	28.	30.	18.	24.	18.	29.	30.	32.5	40.	46.	46.5	38.	45.	46.	70.	59.	70.
11	22.	36.	36.5	3.	19.	24.5	26.	34.	31.	39.	41.	41.	42.	50.	50.5	51.	55.	57.
12	38.	39.	34.5	21.	34.	37.	22.	25.	23.	42.	49.	55.	49.	70.	77.	52.	63.	66.
13	22.	31.	30.	25.	45.	47.	10.	25.	24.	40.	56.	60.	68.	62.	61.	56.5	69.	70.
14	24.5	36.	35.	32.	23.	16.	18.	28.	27.	51.5	66.	58.5	43.	56.	57.	60.	76.	79.
15	36.	38.5	37.	10.	10.5	11.	25.	26.	22.	49.	50.	48.5	45.5	68.	69.	71.	81.	68.
16	40.	42.	35.	16.	24.	25.	20.	30.	28.	35.	44.	47.	60.	81.	82.	65.	78.	70.
17	29.	31.	30.	11.	29.	34.	15.	23.	23.	48.	56.	63.	65.	75.	68.	64.5	70.	67.5
18	34.	43.	38.	29.	35.	35.	19.5	29.	30.	51.	68.	68.5	71.	86.	85.	63.	75.	70.
19	24.	24.5	28.	33.	36.	35.	22.	23.	23.	45.	68.	72.	68.	67.	61.	65.	71.	70.
20	34.	40.	43.	30.	46.	51.	23.	25.	27.5	55.	60.	63.	44.	53.	54.	67.	74.	76.
21	49.	64.	63.	45.	46.	41.	19.	28.	32.	46.	69.	50.	44.	58.5	65.	72.	76.	75.
22	53.	65.	63.	33.	32.	32.	19.	23.	17.	39.	51.5	46.5	56.	71.	76.5	65.	72.	69.
23	60.	50.	41.	29.	48.	50.	7.	17.	18.	35.	38.5	45.	58.	69.	73.	58.	67.	71.
24	32.	34.	28.	38.	54.	60.	6.	23.	24.	35.	47.	54.	66.	81.	82.	63.	71.	73.
25	13.	24.5	24.5	43.	45.	39.	14.	30.	35.	43.	51.	54.	66.	83.	86.	64.5	75.	74.5
26	18.	35.	37.	29.5	24.	25.	33.	41.	42.	44.	59.	60.	71.	82.	71.5	65.	76.	77.
27	24.	44.	42.5	15.	17.	14.5	42.	50.	46.	47.	59.	60.	43.	43.	51.	67.	79.	83.
28	31.	35.	33.	8.	11.	13.	31.	33.	34.	37.	49.	53.	49.	46.	51.	70.	84.5	82.
29	13.	20.5	28.	......	......	......	29.	42.	42.	41.	58.	71.	49.	56.	60.	72.	81.	82.5
30	36.	48.	43.5	......	......	......	37.	39.	40.	60.	55.	55.5	51.	63.5	64.	74.	76.	76.
31	36.	39.	36.	......	......	......	27.	31.	36.	......	......	......	54.	66.5	71.5	......	......	......
Averages	29.4	35.3	33.6	20.8	27.4	27.5	23.6	30.6	30.8	41.	51.5	52.4	52.4	62.5	63.2	65.1	74.5	74.3

READINGS OF THE STANDARD AIR THERMOMETER — (*Concluded*).

1906.	JULY.			AUGUST.			SEPTEMBER.			OCTOBER.			NOVEMBER.			DECEMBER.		
	7 A. M.	12 M	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	63.	75.	79.	66.	82.	81.5	55.	67.	67.	40.	55.	58.5	30.	38.	34.	40.	40.	32.
2	70.	74.	76.	68.	78.	76.	57.	80.	79.	52.	64.	64.	34.5	45.	42.	17.5	23.	23.
3	68.	74.	68.	68.	75.	76.5	68.	74.	73.5	50.	63.	64.	36.	50.	44.	32.	21.	14.
4	63.	72.5	74.	71.	80.	87.	54.	62.	63.	56.	70.	67.	29.5	46.	37.	8.	15.5	15.
5	58.	70.	68.	72.	86.	83.	52.	66.5	73.	62.	71.	73.5	31.	45.	40.	29.	27.	23.
6	58.5	75.	77.	75.	88.	81.	59.	80.	82.	64.	56.	49.	31.	45.	40.5	36.	41.	39.
7	66.	78.	80.5	70.	80.	72.	62.	83.	84.	43.	47.5	47.	32.	45.	39.	10.	9.5	6.
8	68.	80.	82.	70.	77.5	83.	65.	83.	84.	38.	53.	57.	30.	44.	37.	3.	10.	15.
9	66.	68.	79.	73.	83.	86.	68.	87.	85.	58.	50.	47.	30.	41.5	45.5	25.5	23.	22.
10	68.	73.	72.	66.	77.	73.	70.	86.	80.	41.	46.5	39.	39.	45.	43.	30.	36.	37.
11	65.	76.	76.	72.	82.	80.	64.	85.	81.	35.	33.	34.	35.	33.	33.	18.	21.5	18.
12	65.	79.5	81.	64.	68.	70.5	68.	83.	82.	33.	43.	41.	33.	33.	32.	13.	26.	33.
13	69.	83.	84.	58.	72.5	74.	70.	84.	78.	34.	55.	57.	27.	30.	29.	35.	40.	34.
14	70.	83.	85.	63.	77.	75.	55.	60.	62.	41.	59.	66.	22.5	35.	30.	21.	29.	38.
15	70.	80.	78.5	64.	73.5	74.	50.	68.	69.	43.	68.	68.	23.5	32.	31.	42.	40.5	40.
16	71.5	84.	79.	59.	74.	79.5	55.	73.	74.	45.	70.	68.	25.5	34.	33.5	29.	32.	32.
17	69.	69.	74.	69.	83.	83.	57.	74.	81.	47.	63.	55.	28.	39.	39.5	31.	33.	30.
18	67.	76.5	80.	71.	81.	84.	65.	86.5	90.	45.	63.	60.	49.	58.	59.	15.	17.	15.
19	67.	80.	80.	72.	84.	75.	65.	84.	78.	58.	60.	62.	43.	50.	47.5	10.	23.	24.
20	68.	86.5	82.	72.	82.	69.	65.	76.	71.	47.	57.	52.	39.	38.	38.	27.	30.	26.
21	69.5	81.	81.5	71.	83.	84.	69.	82.	78.	41.5	53.	53.	37.	40.	42.	30.	32.	29.
22	72.	86.	89.	73.	87.	88.	66.	80.	79.	54.	62.	60.	44.	41.	41.	25.	25.	20.5
23	71.	78.	75.	75.	88.5	77.	63.	69.5	63.	49.	51.	51.	36.	37.	37.	9.	9.5	8.
24	62.	71.	72.	62.	74.	79.	48.	59.	58.	42.5	53.	55.5	35.	37.5	36.	6.	7.5	8.
25	64.	74.	77.	65.5	72.	74.	49.	62.	66.5	50.	55.	50.	37.	47.	48.	13.	15.	16.
26	65.	78.	78.	70.	80.	84.	55.	67.	68.5	45.	54.	54.	39.	44.	46.	22.5	31.	32.
27	68.5	77.	68.5	71.	68.	67.	59.	69.	69.	52.	58.	58.5	41.5	41.5	41.5	32.	35.	36.
28	67.	80.	77.	61.	72.	77.	49.	68.5	66.	43.	42.	37.5	38.	37.	33.5	33.	40.	35.
29	68.	82.	82.	60.	79.	80.	63.	72.	71.	34.	39.	37.5	23.5	25.	24.5	34.	36.	35.
30	70.	72.5	81.	72.	77.5	77.	58.	56.	56.	36.5	41.	39.	25.	35.	42.	38.	40.	40.
31	67.	80.	80.	62.	71.	71.	......	......	......	32.	33.	33.5	......	......	......	43.	47.	46.
Averages	66.9	77.3	77.9	67.9	78.5	78.1	60.	74.2	73.7	45.5	54.5	53.4	33.4	40.4	38.9	24.4	27.6	26.5

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1906.

DATE.	January. 5 P. M. Max.	January. 5 P. M. Min.	February. 5 P. M. Max.	February. 5 P. M. Min.	March. 5 P. M. Max.	March. 5 P. M. Min.	April. 5 P. M. Max.	April. 5 P. M. Min.	May. 5 P. M. Max.	May. 5 P. M. Min.	June. 5 P. M. Max.	June. 5 P. M. Min.
1	34.5	26.	37.	24.	24.	11.	45.	27.	61.	41.	82.	52.
2	30.	23.	31.	—2.	27.5	16.	44.	25.	69.	44.	73.5	53.
3	32.	19.	22.	—1.	39.	24.	61.	26.	68.5	46.	89.5	59.
4	46.	31.	38.	19.	43.	32.	63.	33.	77.	39.	83.	50.
5	37.	30.	37.	5.	33.	25.	50.	33.	69.	49.	83.	63.
6	35.	25.5	7.	—7.	43.	15.	45.5	31.	62.	47.	81.	63.
7	30.	22.	19.	—7.	40.	30.	45.	26.	58.	39.	83.5	58.
8	23.	10.	30.	—4.	43.	31.	46.5	30.5	52.	33.	92.	67.
9	21.	4.	35.	13.	40.	32.	44.5	36.	51.	40.	91.5	62.
10	34.	5.	27.	17.	35.	28.	48.	36.	47.	35.	80.	57.
11	40.	18.	25.	1.	34.5	22.5	46.5	38.	53.	30.	70.	45.
12	41.	34.	39.	18.	31.	21.	56.	38.5	77.	38.	67.	37.
13	35.	19.	52.	23.	28.	9.	61.	31.	77.	58.	72.	39.
14	36.	20.	47.	16.	30.	16.	67.	45.	61.	41.	81.	45.
15	40.	34.	16.	7.	28.	20.	58.5	46.	72.	36.	86.	60.
16	45.	34.	27.	7.	33.5	19.	48.5	33.	87.	52.	82.	61.
17	35.	27.	34.5	9.	28.5	13.	64.5	34.	83.	55.	70.5	53.
18	45.	26.	36.	24.	31.	16.	70.	43.5	87.5	58.	79.	58.
19	38.	22.	37.	29.5	30.	16.	74.	41.	85.	60.	74.	62.
20	43.	25.	57.	29.	27.5	20.	72.	51.	61.	37.	79.	59.
21	71.	41.	52.	40.	33.	18.	70.	38.	65.	30.	81.	64.
22	69.	48.	41.	30.	32.	13.	54.	34.	77.	45.	76.	58.
23	65.	40.	54.	27.	20.	5.	47.	33.5	76.5	55.	72.5	56.
24	41.	27.	64.	36.	25.	4.	55.	29.	88.5	55.	74.	51.
25	29.	12.	61.	38.	36.	2.	55.	42.	87.5	59.	77.	56.
26	40.	15.	39.	23.	43.	20.	63.	31.	87.	60.	78.	51.
27	48.	21.	25.	14.	51.	39.	63.	35.	72.	42.	83.	57.5
28	43.	29.	17.	7.	46.	31.	60.	31.	52.	45.	89.	63.
29	34.	12.	......	......	43.5	24.	72.	33.	60.	40.	87.	65.5
30	56.	27.	......	......	42.	35.	71.	51.	68.	41.5	83.	70.
31	43.5	34.	......	......	40.5	25.	......	......	74.5	47.0	......	......
Averages	40.6	24.5	36.	16.3	34.9	20.4	57.4	35.4	69.9	45.1	80.	56.5

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1906 — (*Concluded*).

DATE.	July. 5 P.M. Max.	July. 5 P.M. Min.	August. 5 P.M. Max.	August. 5 P.M. Min.	September. 5 P.M. Max.	September. 5 P.M. Min.	October. 5 P.M. Max.	October. 5 P.M. Min.	November. 5 P.M. Max.	November. 5 P.M. Min.	December. 5 P.M. Max.	December. 5 P.M. Min.
1	79.5	55.	85.	54.	71.	49.	63.	34.5	39.	29.	43.	31.
2	81.	63.	82.5	58.5	82.5	48.	69.	46.5	48.	31.	32.	16.
3	79.	60.	80.	66.	79.	61.	66.	45.5	52.	35.	33.	14.
4	76.	62.	88.	66.5	73.5	49.	73.5	55.	49.5	29.	17.	5.
5	74.	55.	93.	66.	74.	42.	79.5	60.	49.5	27.	33.	14.
6	78.	52.	88.	70.	83.	52.	73.5	48.	48.5	30.	52.	21.
7	82.5	59.5	83.	67.	88.	55.	49.5	40.	46.5	30.	39.	5.
8	83.	61.0	84.5	66.	87.	60.	60.	34.	47.	28.	14.5	—1.
9	82.	65.	87.	60.	89.5	61.	58.	46.	46.	24.	27.	13.
10	81.5	65.	86.	65.	90.	64.	47.	37.	51.	37.	37.	20.
11	78.5	55.	84.5	67.	89.	60.	40.	32.	43.	32.	37.	17.
12	82.5	53.	82.	61.3	88.	65.	44.	30.5	33.	31.	33.	8.5
13	86.5	60.	76.	48.	87.	67.	59.	30.	32.	26.5	40.	30.
14	87.	62.	80.	56.	74.	58.	68.	38.	36.5	20.	38.	25.
15	87.	65.	77.5	54.	72.5	40.	75.5	41.	34.	20.	43.	37.
16	85.	64.	81.	47.	75.	44.	78.	43.	36.	25.	41.5	28.
17	79.	66.	88.	60.	83.	53.	68.	45.	40.	23.	33.	26.
18	80.	59.	85.	67.	91.5	61.	68.	43.	60.	38.	30.	14.
19	83.5	54.	86.	70.	90.	61.	63.	57.	62.	42.	29.	7.
20	89.	62.	87.	66.	78.	60.	62.	45.	47.5	37.	31.	19.
21	87.	68.	87.	66.	84.5	68.	61.	40.	42.	35.	33.	25.
22	89.	64.	92.	68.	85.	65.	67.5	49.	55.	38.5	30.	20.
23	89.	68.	91.	68.5	79.	62.	60.	48.	41.	35.	21.	7.
24	77.	54.	79.	60.	64.	46.	58.	37.	48.	34.	11.	1.
25	79.	50.	79.	64.	69.5	38.	61.	49.	52.	28.	16.5	6.
26	81.	55.	84.	65.	74.5	51.	61.	44.	48.	38.	32.	11.
27	83.	60.	84.	64.	72.	57.5	61.	49.	53.	40.	37.5	26.
28	81.	62.	78.	55.	71.	44.	57.	37.	42.	32.	42.	31.
29	86.	63.	82.	51.	72.	57.	40.	33.	33.5	22.	36.	33.
30	83.	67.	80.	63.	71.	53.	41.	34.	43.	16.	44.5	32.5
31	88.	61.	77.	57.	.....	.....	40.	30.	.....	.....	51.	38.
Averages	82.5	60.3	83.8	61.8	79.6	55.1	60.4	42.	45.3	30.4	33.5	18.7

SUMMARY OF MAXIMUM, MINIMUM AND STANDARD AIR THERMOMETERS.

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
Maximum	40.6	36.	34.9	57.4	69.9	80.	82.5	83.8	79.6	60.4	45.3	33.5
Minimum	24.5	16.3	20.4	35.4	45.1	56.5	60.3	61.8	55.1	42.	30.4	18.7
Standard, 7 a. m.	29.4	20.8	23.6	41.	52.4	65.1	66.9	67.9	60.	45.5	33.4	24.4
Standard, 12 m.	35.3	27.4	30.6	51.5	62.5	74.5	77.3	78.5	74.2	54.5	40.4	27.6
Standard, 5 p. m.	33.6	27.5	30.8	52.4	63.2	74.3	77.9	78.1	73.7	53.4	38.9	26.5

AVERAGE MONTHLY AND YEARLY TEMPERATURE SINCE 1882.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	For year.
1883	17.4	22.3	23.6	43.3	52.0	66.6	67.4	65.6	56.3	46.6	39.1	27.5	44.0
1884	17.6	28.3	29.5	40.7	54.3	67.1	66.5	69.9	65.2	50.5	36.5	27.2	46.1
1885	20.6	11.4	18.8	41.2	54.3	63.6	69.7	65.0	58.3	49.2	39.3	27.8	43.3
1886	19.6	22.9	30.2	48.1	55.7	64.0	68.0	67.5	61.8	49.6	36.8	22.2	45.5
1887	20.2	23.2	26.3	41.1	62.5	65.7	75.6	66.5	57.7	47.0	37.6	27.6	45.9
1888	16.4	22.8	24.6	40.8	54.3	66.5	66.8	68.0	62.2	43.9	39.4	29.3	44.6
1889	29.1	18.1	33.9	45.1	58.4	65.3	70.2	66.0	60.5	44.0	40.3	35.2	47.2
1890	31.2	30.9	28.8	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4	46.7
1891	25.9	28.3	30.8	45.3	52.0	66.4	66.4	68.5	66.2	48.3	38.4	35.5	47.7
1892	21.4	25.9	26.5	43.5	52.8	68.6	70.2	69.4	61.2	50.0	35.9	25.2	45.9
1893	15.5	20.6	29.5	41.1	54.1	68.2	69.8	68.8	58.0	52.0	38.2	27.5	45.3
1894	29.7	20.6	38.9	44.1	55.5	67.8	74.2	66.8	64.9	52.7	36.0	31.5	48.6
1895	21.8	16.9	26.9	44.4	59.0	......	......	71.2	61.7	45.4	39.6	31.4	....
1896	22.4	24.1	24.4	49.3	62.0	65.9	71.4	70.0	60.2	56.5	42.9	27.1	48.0
1897	23.2	26.1	33.8	45.0	55.4	62.3	73.6	67.6	62.3	52.6	39.7	29.2	47.6
1898	26.2	26.8	......	43.2	57.0	67.7	74.2	71.0	65.9	52.1	37.9	27.9	....
1899	22.1	20.4	30.4	46.6	57.6	69.5	71.2	71.6	60.6	53.5	38.9	30.0	47.7
1900	26.0	22.6	23.6	43.5	56.7	68.4	72.6	74.1	66.1	57.9	41.1	28.7	48.4
1901	26.1	18.5	32.2	46.5	56.9	68.9	76.6	71.0	64.0	51.4	34.3	27.7	47.9
1902	23.2	22.2	39.5	46.6	56.1	63.2	71.2	67.6	63.6	43.1	46.3	25.7	47.4
1903	25.7	28.1	42.4	45.9	60.4	63.2	70.8	65.5	64.4	52.5	36.2	23.3	48.2
1904	18.9	23.1	30.9	41.4	60.3	67.8	70.0	68.2	61.9	48.4	36.9	22.5	45.9
1905	19.8	18.9	33.1	44.8	57.5	66.4	71.8	68.7	63.7	52.4	37.6	32.0	47.2
1906	32.5	26.1	27.6	46.4	57.5	68.2	71.4	72.8	67.3	51.2	37.9	26.1	48.8
Monthly averages	23.	22.9	29.8	44.2	56.5	66.5	70.8	68.7	62.3	50.	38.5	27.9	....

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1906 INCLUSIVE.

(Highest and Lowest Record for Each Month in Heavy Type.)

	JANUARY.				FEBRUARY.				MARCH.				APRIL.			
	Max.		Min.		Max.		Min.		Max.		Min.		Max.		Min.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883..........	18.	44.	11.	—9.	17.	48.	24.	—2.	19.	61.	9.	2.	16.	75.	1.	19.
1884..........	14.	42.	26.	—13.	7.	55.	29.	—3.	30.	54.	1.	—4.	28.	74.	1.	23.
1885..........	1.	61.	29.	—6.	10.	38.	11.	—11.5	28.	48.	13.	—11.	24.	84.5	10.	20.5
1886..........	5.	52.5	13.	—18.7	9.	50.	27.	—11.	16.	58.	2.	—2.5	24.	80.5	4.	22.
1887..........	24.	50.7	19.	—8.	9.	54.2	27.	—4.	3.	51.7	1 & 5	8.7	11.	75.7	1.	17.2
1888..........	2.	43.2	23.	—6.	21.	49.	10.	—7.	28.	57.	13.	0.	29.	82.5	8.	19.
1889..........	18.	55.	20.	5.	23.	42.	4 & 24	—7.	28.	61.8	30.	18.5	20.	84.	1.	26.
1890..........	6.	67.	29.	9.	5.	64.5	11 & 21	9.5	13.	62.	8.	2.	13.	78.8	1 & 19	23.
1891..........	3.	46.	17.	4.	26.	56.8	15.	2.5	12.	57.	2.	4.5	28.	81.4	7.	21.
1892..........	3.	48.	10.	—5.	15.	44.	6.	2.8	27.	52.2	4.	6.	6.	78.	17.	25.5
1893..........	29.	46.	11.	—6.	15.	47.4	5.	—1.	24.	54.	5.	9.	13.	75.3	26.	25.
1894..........	5.	59.	13.	11.	20.	47.6	27.	—8.5	18.	73.	26.	15.	21.	71.3	2.	20.
1895‡.........	7.	45.	19.	4.	25.	46.	8.	—14.	25.	52.	5 & 16	12.	30.	80.	3.	28.
1896..........	30.	44.	6.	—16.5	29.	49.	17.	—21.	31.	56.5	24.	—2.	17.	87.	4 & 5	19.
1897..........	5.	58.	20.	—3.5	18.	49.5	1 & 27	5.5	21.	64.	1.	—1.	26.	82.	20.	19.
1898..........	13.	57.	30 & 31	—4.	12.	56.5	2 & 3	—2.	11.	*65.	2.	17.5	14 & 18	69.	5.	18.
1899..........	5.	59.	12.	—4.	21.	52.5	11.	—8.	13.	63.	21.	13.	30.	82.	3.	23.
1900..........	23.	56.	1.	2.	14.	57.	27.	0.	10.	46.	12.	—3.	30.	†73.5	9.	†22.
1901..........	16.	48.	20.	—2.	16.	36.	24.	—2.5	24.	67.	6.	—1.	28.	78.	12.	28.
1902..........	3.	44.	28.	2.	28.	52.	6.	—3.	12.	66.5	19.	14.	22.	87.	5.	25.
1903..........	3.	48.	9.	—2.	28.	62.5	18.	—4.	19.	78.5	1 & 2	19.	30.	86.	5.	21.
1904..........	23.	48.	19.	—14.	7.	58.	16.	—18.	26.	58.	4.	8.	24.	67.5	14.	16.
1905..........	1.	49.	26.	—2.	20.	45.	5 & 14	—6.	29.	82.	5.	1.	27 & 28	75.	16.	23.
1906..........	21.	71.	9.	4.	24.	64.	6 & 7	—7.	27.	51.	25.	2.	19.	74.	2.	25.

* Maximum for first eleven days only. Record incomplete.

† Thermometers broken. Record not taken from April 19th to 24th inclusive.

‡ Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1906 INCLUSIVE — (*Continued*).

(Highest and Lowest Record for Each Month in Heavy Type.)

	May.				June.				July.				August.			
	MAX.		MIN.		MAX.		MIN.		MAX.		MIN.		MAX.		MIN.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	11.	87.	1 & 14	31.	7.	86.5	2.	42.	5.	89.	1.	46.	23.	92.	15.	46.
1884	24.	88.	30.	32.	25.	90.5	15.	41.	2.	87.5	15.	50.5	20.	95.	25.	44.
1885	18.	81.7	3.	27.5	14.	86.5	23.	41.5	18.	90.5	12.	46.5	1.	89.	28.	45.
1886	23.	79.5	17 & 18	37.2	14.	86.2	1.	42.2	7.	95.	1.	45.2	30.	91.5	6.	47.7
1887	23.	88.2	14.	37.5	17.	89.2	15.	47.7	3.	95.5	11.	58.7	3.	88.5	8.	46.
1888	13.	79.8	3.	29.	23.	94.1	4.	40.	5.	89.8	16.	47.	9.	92.6	23.	48.3
1889	18.	91.8	29.	32.	22.	85.	5.	46.	11.	90.7	6.	50.5	31.	86.7	16 & 17	50.3
1890	4.	80.7	2.	30.	30.	85.6	8.	44.8	9.	94.5	24.	46.5	4.	96.2	24.	46.0
1891	11.	85.5	4.	29.5	16.	95.	6.	40.	14.	92.	31.	46.	12.	92.	29.	46.5
1892	31.	78.	9.	34.2	14.	92.	11.	45.8	29.	96.3	2.	46.4	10.	95.5	28.	49.
1893	25.	88.	9.	35.	21.	94.	1.	44.	26.	95.5	24.	48.4	11.	94.5	13.	49.
1894	2.	85.4	14.	32.6	23.	91.6	6.	39.	21.	97.	10.	49.6	25.	93.	27.	45.3
1895*	31.	92.	13 & 21	36.	3.	96.	7.	54.	8.	94.	11.	52.	11.	88.	22.	44.
1896	11.	87.5	7 & 20	40.	21.	89.	3.	41.	3.	94.	18.	49.	6 & 7	96.	29.	44.
1897	24.	80.	8.	32.5	24 & 25	87.5	2.	42.	11.	97.	15.	57.	15.	87.5	21.	46.
1898	29.	79.	6.	34.	9.	90.	16.	40.	4.	96.5	12.	40.	24.	90.5	28.	47.
1899	2.	87.5	15.	32.5	6 & 24	93.	11.	41.5	4.	97.5	1.	50.	20.	97.5	15.	44.5
1900	15 & 16	88.5	7.	27.	25.	93.	10.	45.	17.	96.	1.	50.	11.	97.	2.	51.
1901	23.	78.	16.	36.	27, 28 & 29	95.5	2.	42.	1.	97.5	20.	54.5	22.	90.	5.	52.
1902	22.	90.	11.	26.	3.	85.	6.	38.	14 & 27	90.	1.	53.	31.	90.	13.	47.
1903	19.	89.	2.	24.	30.	86.5	1.	39.	9.	94.	15.	50.	18.	85.5	8 & 14	45.
1904	25.	88.	12.	31.5	5–24 & 25.	89.	12 & 17	45.	19.	93.	3.	49.	25.	89.5	19.	45.
1905	3.	82.	2.	29.5	19.	90.	1.	40.	18.	92.	22.	48.5	10.	93.	27.	41.
1906	24.	88.5	11 & 21	30.	8.	92.	12.	37.	20–22 & 23	89.	25.	50.	5.	93.	16.	47.

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1906 INCLUSIVE — (*Concluded*).

(Highest and Lowest Record for Each Month in Heavy Type.)

	SEPTEMBER.				OCTOBER.				NOVEMBER.				DECEMBER.			
	MAX.		MIN.		MAX.		MIN.		MAX.		MIN.		MAX.		MIN.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883..........	17.	80.	11.	37.	11.	78.	17 & 18	25.	22.	70.	17.	13.	9 & 14	56.	23.	—7.5
1884..........	5.	94.	14.	36.	5.	84.2	27.	23.	11.	62.	25.	15.	31.	55.5	20.	—15.5
1885..........	27.	83.7	24.	40.	1.	79.	31.	25.	8 & 13	68.	28.	18.	24.	53.	9.	4.
1886..........	11.	89.5	22.	40.	10.	76.7	17.	27.5	3.	68.2	28.	17.	11 & 25	46.	6.	—6.
1887..........	22.	81.7	27.	37.2	9.	78.5	31.	21.2	28.	68.	30.	15.	12.	54.7	2.	—3.
1888..........	1 & 10	83.	7.	40.	6.	62.7	22.	29.	1 & 3	73.	23.	8.	27.	53.	22.	4.
1889..........	4.	84.	22 & 23 & 29	40.	2.	68.7	24.	21.2	4.	61.7	17.	17.8	25.	60.5	4 & 5	8.
1890..........	8.	83.6	25.	35.5	5.	69.8	31.	32.	8.	65.4	28.	17.	1.	46.2	20.	3.
1891..........	26.	92.8	30.	43.	4.	89.4	12 & 25	27.	1.	68.	29.	12.	5.	57.7	18.	7.
1892..........	26.	88.	20.	39.	1.	82.	2.	33.1	19.	60.	24.	18.	9.	49.2	27.	—3.7
1893..........	5.	80.	26.	37.4	13.	76.	31.	25.	3.	62.2	27.	19.	26.	62.	14.	1.5
1894..........	4.	90.	26.	33.	1.	76.5	15.	33.	3.	65.	29.	12.	17.	59.	29.	—0.2
1895*.........	4.	94.	15 & 30	42.	2.	72.	30.	28.	7.	68.	21.	19.	20 & 21	62.	13.	—2.
1896..........	12.	95.	23.	36.	30.	77.5	10 & 19	29.	19.	70.	21.	19.5	14.	58.	28.	2.
1897..........	11.	98.	21.	37.5	16.	88.	10 & 18	30.	6.	65.	24.	16.5	12.	61.5	24.	2.
1898..........	4.	94.	21.	40.5	1.	85.5	28.	31.	5.	63.	28.	16.	31.	54.	14.	3.
1899..........	4.	92.	15 & 30	30.	15.	86.	3.	26.	19.	60.	14.	25.	12.	60.	31.	—1.
1900..........	12.	95.	19.	37.	6 & 7	89.	20.	28.	22.	70.	17.	19.	4.	55.	10 & 14	4.
1901..........	6.	89.	26.	36.	10 & 11	74.	28.	28.	1.	65.	27.	13.	14.	62.	18.	—1
1902..........	1.	90.	15.	38.	19.	74.	10 & 22 & 30	29.	14.	73.	29.	22.	2.	52.	9.	—5.
1903..........	14.	90.	29.	35.	1.	73.	25 & 27	28.	4.	70.	26 & 27	12.	3.	46.	19.	—4.
1904..........	3.	88.	23.	33.	10.	81.	31.	22.	3.	65.	29.	9.	23.	53.	16.	—2.
1905..........	30.	88.5	26.	36.	1.	85.	26.	20.5	12.	61.	14.	11.	29.	52.5	15.	1.
1906..........	18.	91.5	25.	38.	5.	79.5	13 & 31	30.	19.	62.	30.	16.	6.	52.	8.	—1.

Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.

YEARLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1906 INCLUSIVE.

(Highest and Lowest Record for Each Month in Heavy Type.)

	Maximum for Each Year.		Minimum for Each Year.	
	Date.	Temp.	Date.	Temp.
1883	Aug. 23	92.	Jan. 11	—9.
1884	Aug. 20	95.	Dec. 20	—15.5
1885	July 18	90.5	Feb. 11	—11.5
1886	July 7	95.	Jan. 13	—18.7
1887	July 3	95.5	Jan. 19	—8.
1888	June 23	94.1	Feb. 10	—7.
1889	May 18	91.8	Feb. 4 and 24	—7.
1890	Aug. 4	96.2	Mar. 8	2
1891	June 16	95.	Feb. 15	2.5
1892	July 29	96.3	Jan. 10	—5.
1893	July 26	95.5	Jan. 11	—6.
1894	July 21	97.	Feb. 27	—8.5
1895‡	June 3	96.	Feb. 8	—14.
1896	Aug. 6 and 7	96.	Feb. 17	—21.
1897	Sept. 11	98.	Jan. 20	—3.5
1898	July 4	96.5	Jan. 30 and 31	—4.
1899	July 4 and Aug. 20	97.5	Feb. 11	—8.
1900	Aug. 1	97.	Feb. 27	0.
1901	July 1	97.5	Feb. 24	2.5
1902	May 24, July 14 and 27, August 31 and Sept. 1	90.	Dec. 9	—5.
1903	July 9	94.	Feb. 18 and Dec. 19	—4.
1904	July 19	93.	Feb. 16	—18.
1905	Aug. 10	93.	Feb. 5 and 14	—6.
1906	Aug. 5	93.	Feb. 6 and 7	—7.

RAINFALL BY MONTHS SINCE 1882.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1882	......	......	......	......	......	3.69	2.42	2.37	1.25	0.62	1.22	0.55	......
1883	0.48	1.44	0.88	1.58	4.45	4.12	2.98	3.47	2.12	2.10	1.54	0.73	25.89
1884	1.83	2.01	2.54	0.83	2.49	2.01	2.33	1.44	3.17	1.67	1.01	0.97	22.30
1885	1.07	0.61	0.12	1.26	1.58	2.49	4.64	5.02	2.11	2.88	1.36	0.76	23.90
1886	1.13	0.95	1.13	4.13	1.92	2.92	4.41	2.86	2.31	1.79	3.48	1.24+	27.87
1887	0.18	2.97	0.48	1.37	0.46	2.01	6.37	3.03	0.75	1.74	1.58	1.35	22.29
1888	0.78	1.04	1.43	3.09	2.79	3.88	0.99+	4.02	2.73	3.47	2.02	1.24	27.48
1889	2.99+	0.25	0.66+	3.28	1.21	7.47	4.57	1.98	2.50	3.32	3.44	1.62	32.28
1890	2.16	1.45	2.16	2.20	5.49	5.26	1.07	4.34	5.81	4.54	2.40	......	36.88
1891	1.44	1.57	3.25	1.63	0.49	4.31	3.52	3.16	0.47	2.65	0.74	3.29	27.52
1892	0.57	0.88	0.55	0.67	4.04	3.95	1.89	4.77	1.12	1.34	1.67	0.72	23.17
1893	1.62	3.71	1.94	2.59	4.92	3.08	3.68	5.38	2.68	1.59	1.09	1.56	33.84
1894	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.64	3.59	0.43	0.47	29.36
1895	0.96	......	0.29	1.36	2.88	......	......	2.66	0.94	0.72	2.31	2.49	......
1896	1.19	2.28	0.84	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	27.61
1897	0.64	0.21	2.12	1.90	2.19	3.16	5.28	1.27	2.36	0.73	2.53	1.39	23.78
1898	1.74	0.33	1.54	2.03	1.90	2.37	1.32	3.60	1.86	3.83	2.03	0.33	22.90
1899	0.37	0.30	1.22	1.12	1.69	1.71	4.15	1.05	2.23	2.69	1.36	1.46	19.35
1900	1.43	2.42	0.02	0.95	1.71	1.45	6.53	1.75	0.91	3.65	6.13	0.78	27.73
1901	0.72	......	2.19	4.43	3.80	2.07	3.97	5.52	2.46	1.35	2.09	3.37	31.97
1902	0.86	0.66	1.94	1.92	2.84	4.33	5.29	2.41	2.88	2.32	0.74	0.74	26.89
1903	1.81	1.11	5.60	2.60	0.23	7.77	4.86	7.21	1.30	4.19	1.63	0.38	38.69
1904	0.80	1.03	2.41	1.67	4.04	3.37	5.73	2.56	3.26	2.06	0.26	1.42	28.61
1905	0.40	0.27	1.09	2.05	2.01	8.78	3.59	5.44	1.90	3.69	1.32	1.84	32.38
1906	1.46	0.53	1.60	2.08	4.24	5.31	2.37	3.68	2.16	3.56	1.40	1.54	29.93

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